R E P O R T R E S U M E S

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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XI, PART I--MAINTAINING THE FUEL SYSTEM (PART I), CUMMINS DIESEL ENGINES, PART II--UNIT REPLACEMENT (ENGINE).

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF DIFFERENCES BETWEEN TWO AND FOUR CYCLE ENGINES, THE OPERATION AND MAINTENANCE OF THE DIESEL ENGINE FUEL SYSTEM, AND THE PROCEDURES FOR DIESEL ENGINE REMOVAL. TOPICS ARE (1) REVIEW OF TWO CYCLE AND FOUR CYCLE CONCEPT, (2) SOME BASIC CHARACTERISTICS OF FOUR CYCLE ENGINES, (3) THE CUMMINS FUEL SYSTEM, (4) PREPARATION FOR REMOVAL, AND (5) UNIT REMOVAL. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "UNDERSTANDING BASIC HYDRAULICS IN RELATION TO CUMMINS FUEL PUMPS" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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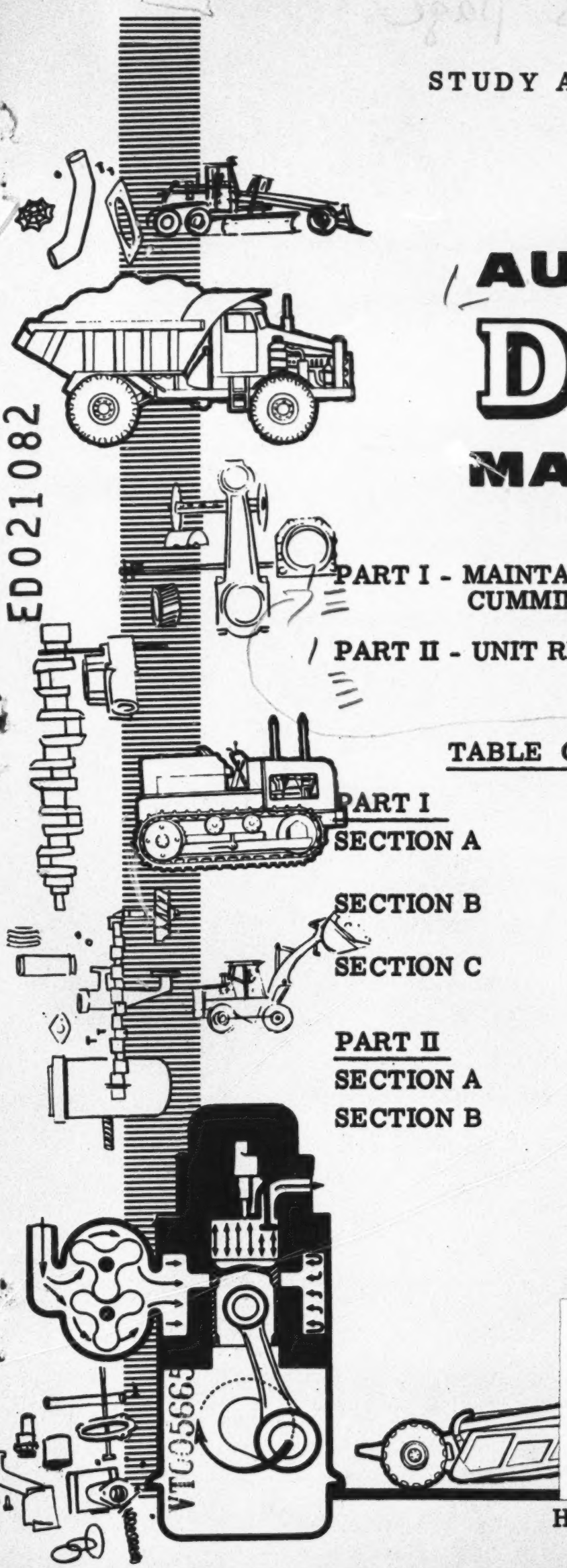

STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 1

PART I - MAINTAINING THE FUEL SYSTEM (PART I) CUMMINS DIESEL ENGINES

PART II - UNIT REPLACEMENT (ENGINE)

UNIT XI

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HUMAN ENGINEERING INSTITUTE

PART I - MAINTAINING THE FUEL SYSTEM (PART I) -- CUMMINS DIESEL ENGINE

SECTION A -- REVIEW OF TWO CYCLE AND FOUR CYCLE CONCEPT

Up to this point in the program most of the units have emphasized the two cycle (GM) type of engine. The four cycle engine has been mentioned briefly, but only to compare it with the two cycle.

This unit is the first of ten units that will cover the Cummins four cycle engine in depth. The latter portion of each unit will also cover other areas of importance to the maintenance mechanic.

CUMMINS MODEL DESIGNATIONS -- Cummins diesel engines are built in several series. There is the V series, L series (low speed), and the H series. This unit will cover only the V and H series. The H series (inline) is further classified as NH, NHR, NHRS, and NT, the difference being that the R is a revised model, the S indicates supercharged, and the T means turbocharged.

The H series covers the middle power range of approximately 100 to 390 horsepower. They are comparable to the GM inline 71 engine and sometimes come equipped with some type of a cold water starting aid.

The first V series Cummins engine was designated NVH-450. Later, a new V block was designed to get greater horsepower. They call this the V-12-525. It is a naturally aspirated engine. The V series also comes equipped with a turbocharger and is designated with a T, such as VT 12-635 or 700 series. (This is not a naturally aspirated engine.) The new series V 12 and VT 12 use basically the same engine block. More will be said about the turbocharger in a later unit.

TWO CYCLE VS FOUR CYCLE -- As we have learned, the two cycle (GM) completes the intake compression power and exhaust in two cycles of the pistons, See Figure 1.

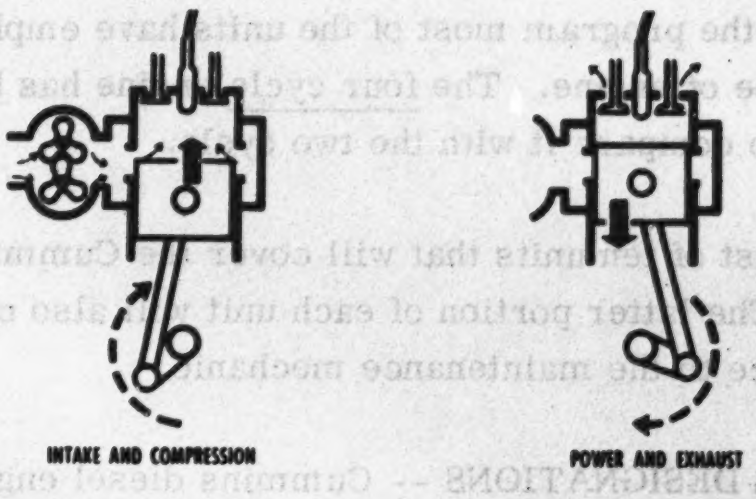


Fig. 1 Two cycle principle.

The four cycle engine devotes a full piston stroke for each operation; intake, compression, power, and exhaust, see Figure 2.

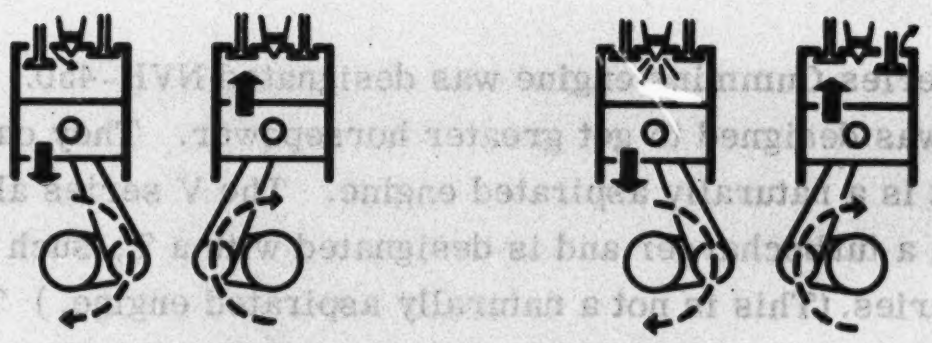


Fig. 2 Four cycle operation.

SECTION B -- SOME BASIC CHARACTERISTICS OF FOUR CYCLE ENGINES

Theoretically, the two cycle engine appears to be superior to the four cycle engine, as it has a power stroke for every revolution of the crankshaft against one for every two revolutions of the four cycle engine. The engine with a four stroke cycle also requires a much heavier flywheel, as two strokes are required for driving out the exhaust gases and refilling the cylinder with a fresh supply of air. The power for this work is stored in the flywheel on the power stroke and then given up on the exhaust and compression stroke. In two cycle engines the scavenging air is supplied by a separate blower which requires considerable power for it's operation, offsetting it's apparent advantages.

The earlier developed two-cycle engine has one serious disadvantage over the four-cycle engine in that it was much more difficult to cool. This is due to having a combustion stroke for each revolution of the crankshaft as against two revolutions for the four-cycle engine. The heat created by this extra combustion stroke had to be absorbed by the cylinder walls and pistons. However, with today's modern two-cycle engine having a cooling capacity large enough to overcome this problem, this disadvantage no longer exists.

SECTION C -- THE CUMMINS FUEL SYSTEM

The single disk, distributor-type fuel system was the first fuel system to be used on the Cummins engine. Some of these may still be in use on a few applications today. Later, another type known as the double-disk (DD) fuel system was introduced, many of this type are still being used. Today, and in fact since 1954, all engines manufactured by the Cummins people come equipped with what is known as the pressure-time (PT) type of fuel system. For purposes of this course we will cover only the PT type of system.

The operation of the PT system is based on the basic principle of hydraulics, that by changing the pressure of a liquid flowing through a pipe, you can change the amount of liquid coming out of the open end. Decreasing the pressure decreases the flow or amount of liquid delivered. In a PT system, this theory is put to work by the following four requirements:

1. A fuel pump to move fuel.
2. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so the individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Passages to distribute the fuel supply lines, drilled passages, and a drain line.
4. A means of introducing the fuel into each combustion chamber -- injectors.

TYPES OF PT SYSTEMS -- There are two types of PT fuel systems. The first type called PTR, see Figure 3, stands for pressure time regulated. The second type called PTG, see Figure 4, stands for pressure time governor controlled.

The PTR fuel pump can be identified by the presence of a fuel return line from the top of the fuel pump housing to the supply tank.

The PTG fuel pump can be identified by the absence of a fuel return line at the top of the pump.

The PTR fuel pump assembly is made up of four main units:

1. The gear pump which draws fuel from the supply tank forcing it through the pump filter screen into the pressure regulator valve.
2. A pressure regulator which limits the pressure of the fuel to the injectors.

3. The trottle which provides a manual control of fuel flow to the injectors under all conditions in the operating range.

4. The governor assembly which controls the flow of fuel from idle to maximum governed speed.

The PTG fuel pump assembly is made up of three main units:

1. The gear pump which draws fuel from the supply tank and forces it through the pump filter screen to the governor.

2. The governor which controls the flow of fuel from the gear pump, as well as the maximum engine speed.

3. The trottle which provides a manual control of fuel flow to the injectors under all conditions in the operating range.

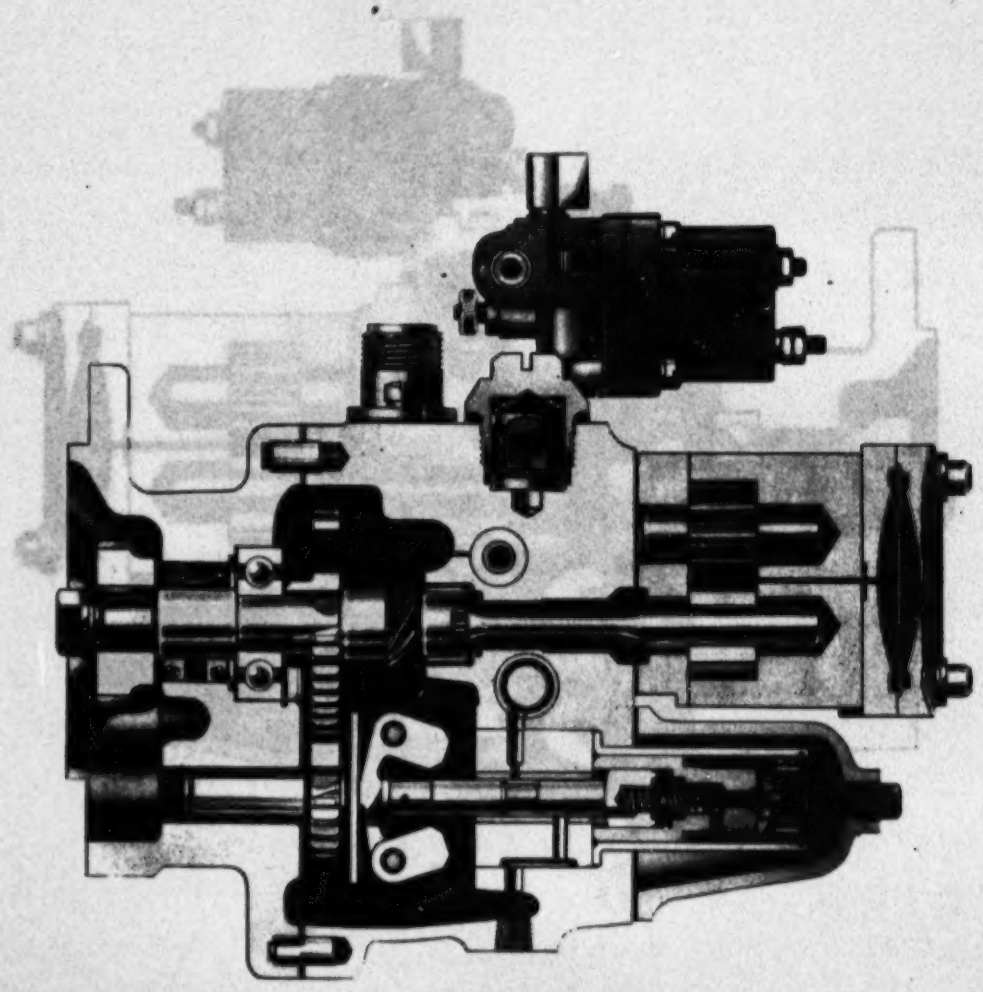


Fig. 3 Cross section PTR fuel pump.

GEAR PUMP AND PULSATION DAMPER -- The gear pump performs the same function on both the PTR and PTG fuel pumps.

This assembly, located at the rear of the fuel pump and driven by the pump main shaft, consists of a single set of gears to pick up and deliver fuel throughout the fuel system. The pulsation damper at the rear of the fuel pump consists of a spring steel diaphgram confined between shallow chambers, sealed by an "O" seal ring on either side. Fuel under pressure admitted to the damper makes contact with the diaphgram which yields to the pulsations, thus, smoothing the fuel flow. From the

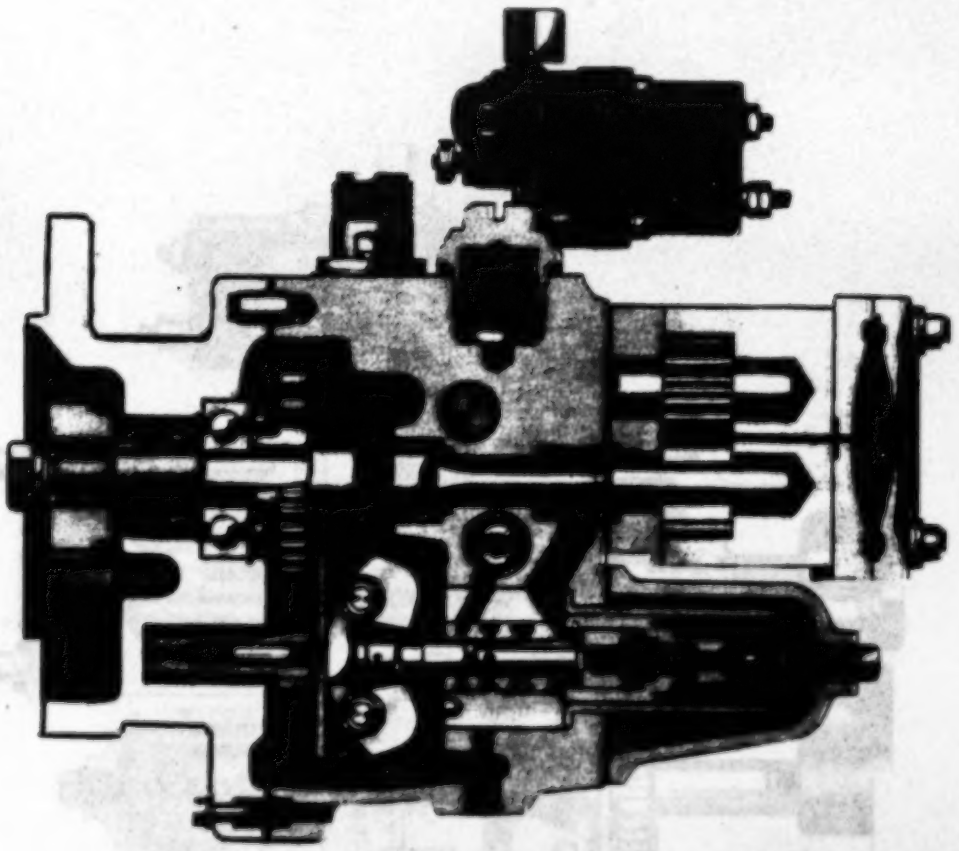


Fig. 4 Cross section PTG fuel pump.

gear pump, fuel flows through the filter screen and:

1. In the PTR pump, to the pressure regulator assembly as shown in Figure 5.
2. In the PTG pump, to the governor assembly as shown in Figure 6.

PRESSURE REGULATOR -- The pressure regulator, used only in the PTR fuel pump, functions as a bypass valve to regulate the fuel pressure to the injectors. Bypassed fuel flows back to the suction side of the gear pump, see Figure 5.

THROTTLE -- In both fuel pumps, the throttle provides a means for the operator to manually control engine speed above idle, as required by varying operating conditions of speed and load.

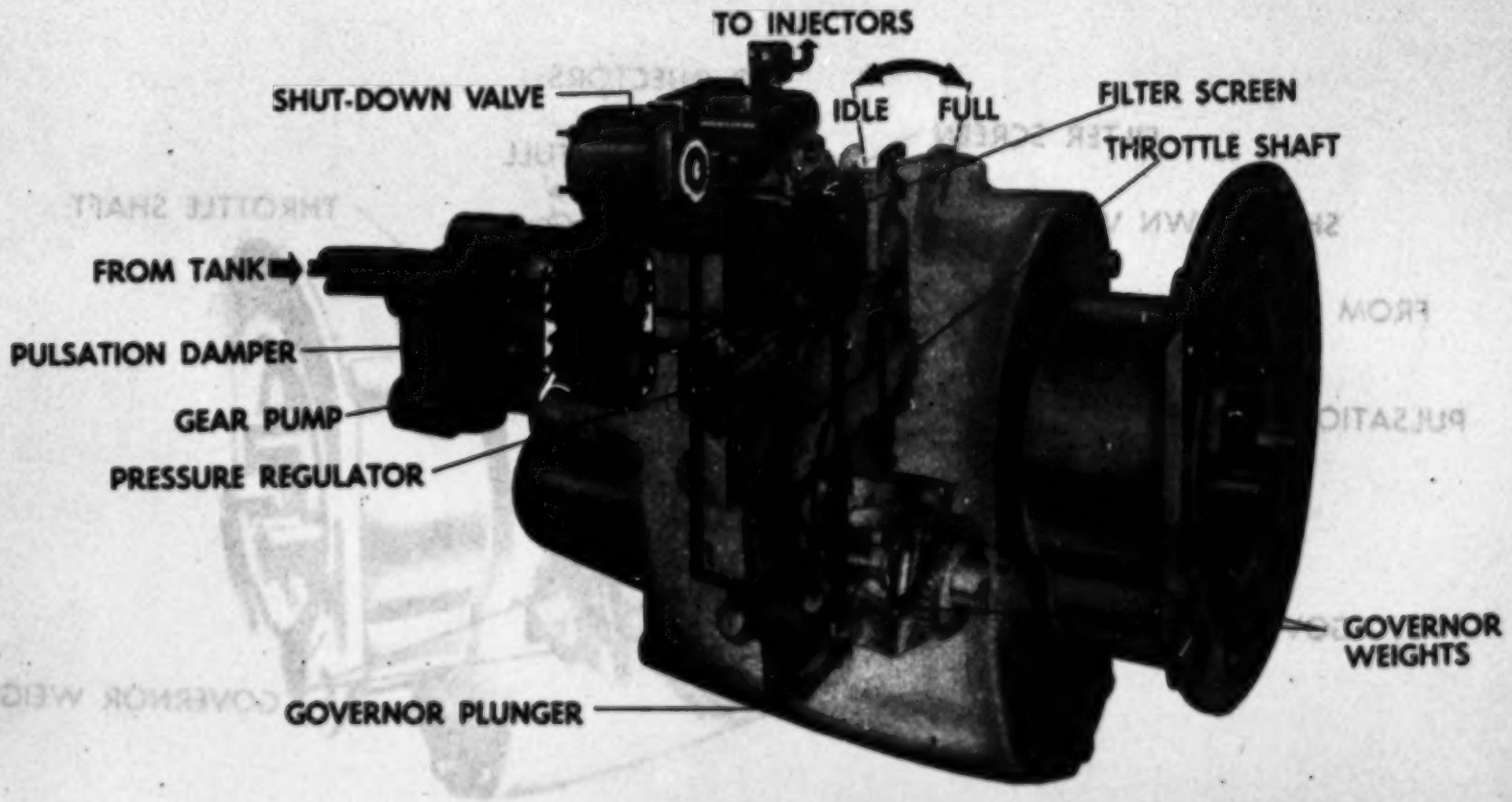


Fig. 5 Fuel flow through PTR fuel pump.

In the PTR pump, fuel flows past the pressure regulator to the throttle shaft. Under idling conditions, fuel passes around the shaft to the idle port in the governor barrel. For operation above idle speed, fuel passes through the throttling hole in the shaft and enters the governor barrel through the main fuel port.

In the PTG pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, around the throttle sleeve. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the shaft.

GOVERNORS -- The mechanical governor, identical on both PTR and PTG fuel pumps, is actuated by a system of springs and weights and has two functions. First, the governor maintains sufficient fuel for idling

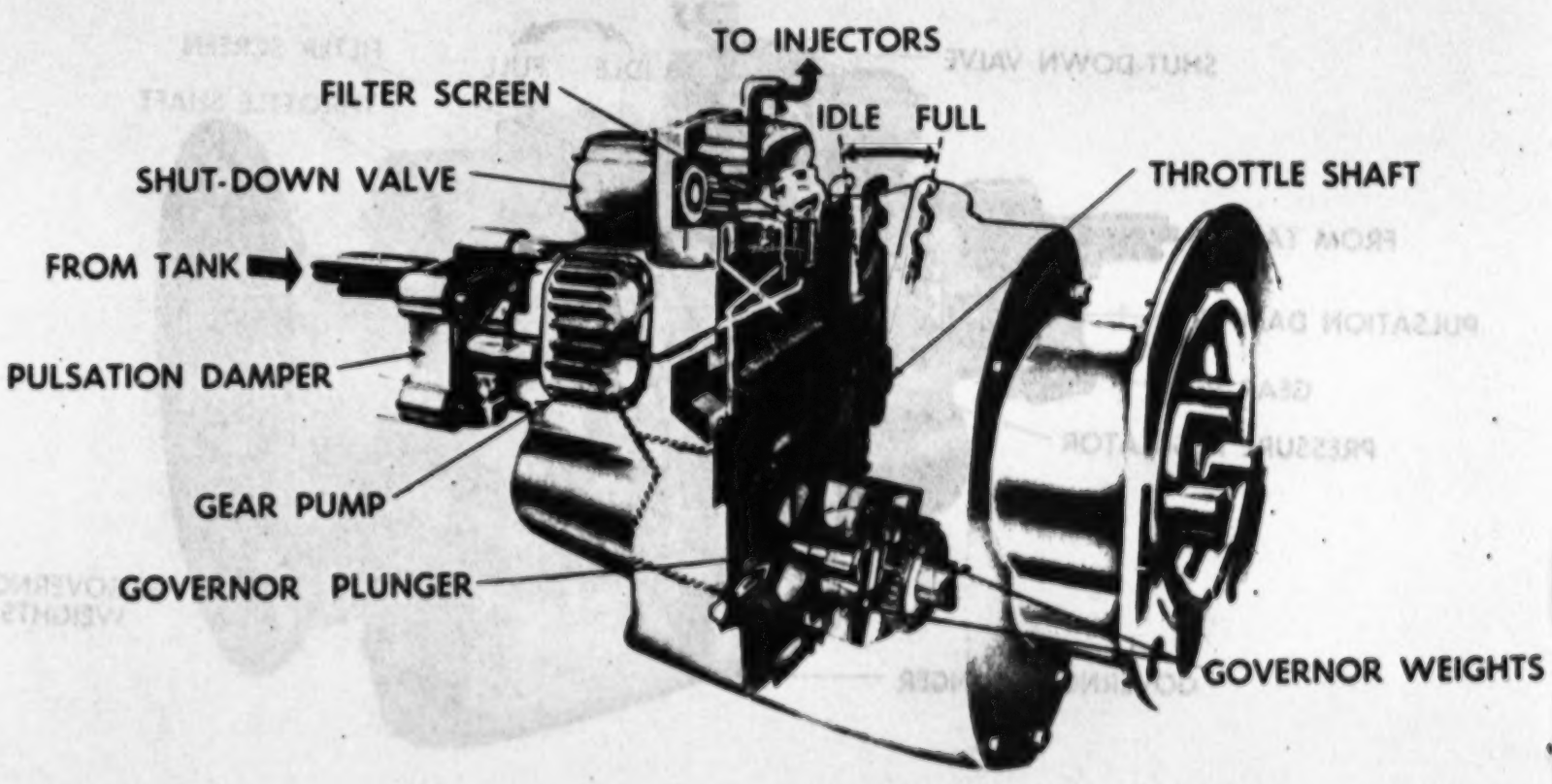


Fig. 6 Fuel flow through PTG fuel pump.

with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. . The idle springs in the governor spring pack position the governor plunger so the idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors in accord with the engine requirements as controlled by the throttle and limited by the pressure regulator of PTR fuel pumps and size of the idle spring plunger counterbore on PTG fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shutdown valve, inlet supply lines and on into the injectors.

PTR VARIALBE SPEED MECHANICAL GOVERNOR -- On some applications this governor replaces the standard mechanical governor to meet the requirements of machinery on which the engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Figure 7.

As a variable speed governor, this unit is suited to the varying speed requirements of cranes, shovels, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed speed machines.

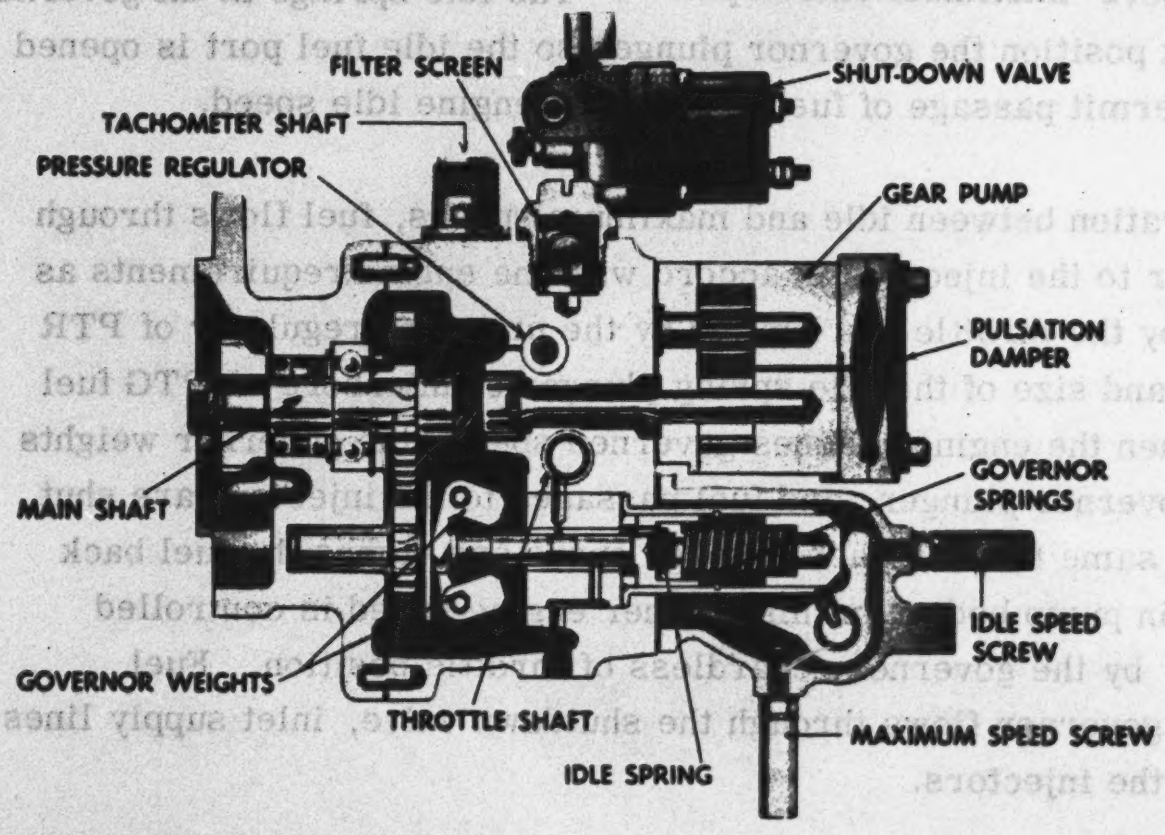


Fig. 7 PTR fuel pump with variable speed governor.

As a constant speed governor, this unit provides control for pumps, non-parallel generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

PTG VARIABLE SPEED MECHANICAL GOVERNOR -- The PTG variable speed governor performs the same function when used with the PTG pump as described above; however, a standard mechanical governor spring pack must be used on the PTG pump in addition to the variable speed governor.

The variable speed governor assembly mounts atop the fuel pump, and the fuel solenoid is mounted to the governor housing, see Figure 8.

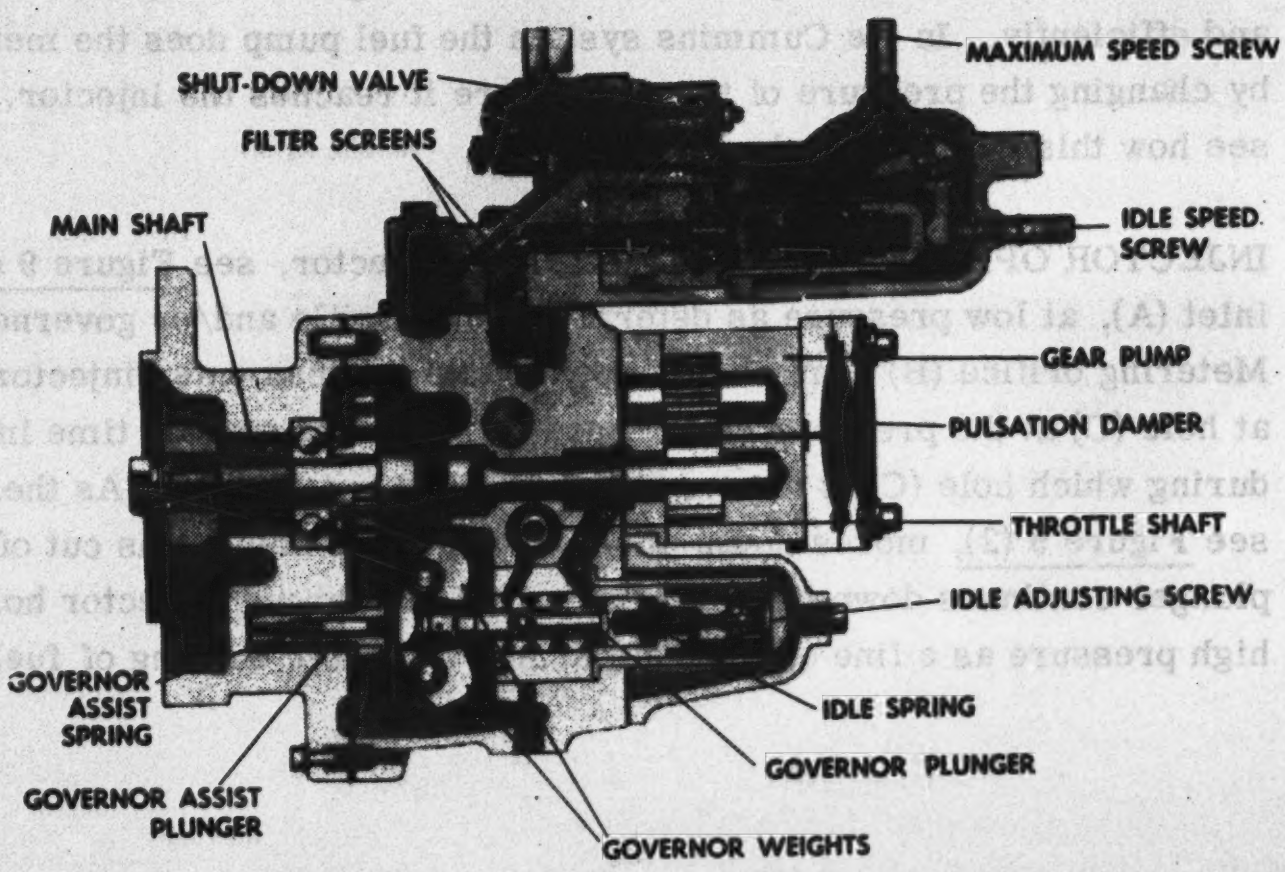


Fig. 8 PTG fuel pump with variable speed governor.

Fuel from the fuel pump body enters the variable speed governor housing and flows to the governor barrel and plunger. Fuel flows past the plunger to the shut-down valve and on into the injector according to governor lever position, as determined by the operator.

The variable speed governor cannot produce engine speeds in excess of the mechanical governor setting. The governor can produce idle speeds below the standard pump idle speed setting, but should not be adjusted below the standard fuel pump speed setting when operating as a combination mechanical and variable speed governor.

CUMMINS FUEL INJECTORS -- One of the differences between the Cummins fuel system and the GM fuel system is that the Cummins injector does not meter the fuel in the same manner as the GM. Metering as we know is measuring of the fuel. The exact amount of fuel must be delivered to each cylinder for each power stroke if the engine is to operate smoothly and efficiently. In the Cummins system the fuel pump does the metering by changing the pressure of the fuel before it reaches the injector. Let's see how this is accomplished.

INJECTOR OPERATION -- Fuel enters the injector, see Figure 9 (1), at inlet (A), at low pressure as determined by throttle and/or governor. Metering orifice (B) controls quantity of fuel that can enter injector cup at hole (C) at the pressure determined by fuel pump and the time interval during which hole (C) is uncovered by the injector plunger. As the plunger, see Figure 9 (2), moves down, fuel entry into cup hole (C) is cut off. As plunger continues down it forces fuel out of cup through injector holes at high pressure as a fine spray that permits complete burning of fuel in the

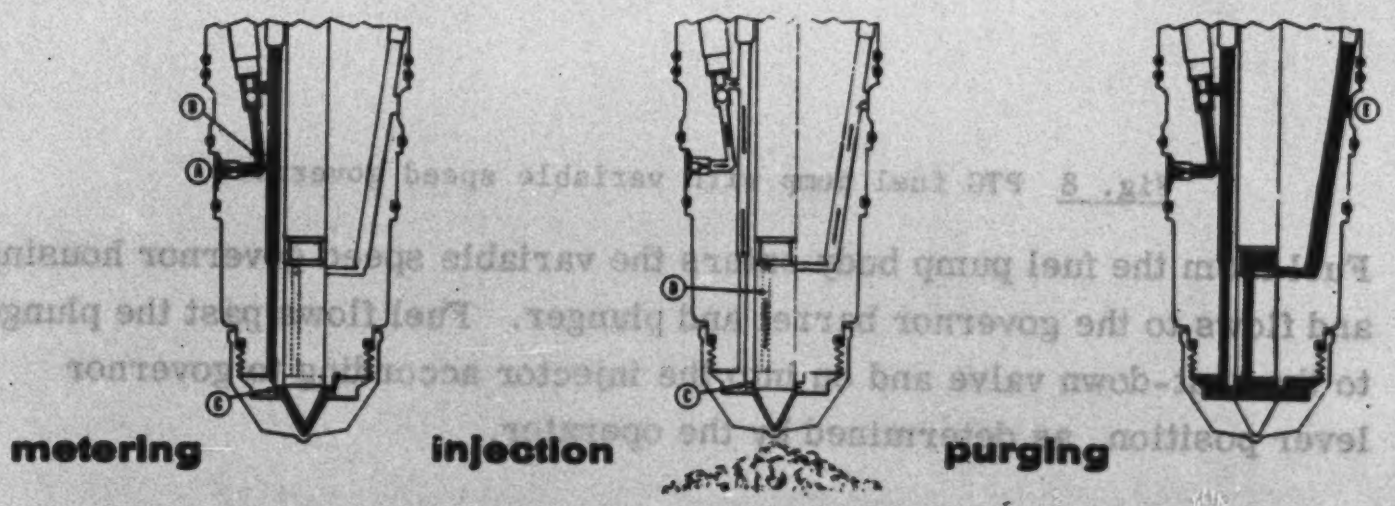


Fig. 9 Operation of Cummins fuel injector.

combustion chamber. When hole (D) is uncovered by the undercut, fuel begins to flow through the return passage and returns to the fuel tank. After injection, see Figure 9 (3), the plunger remains seated until the next metering and injection cycle. Fuel flows freely through the injector and is returned to the fuel tank through passage (E). This provides cooling of the injector and also warms the fuel in the tank. The timing of metering and injection is determined by the engine camshaft, see Figure 10.

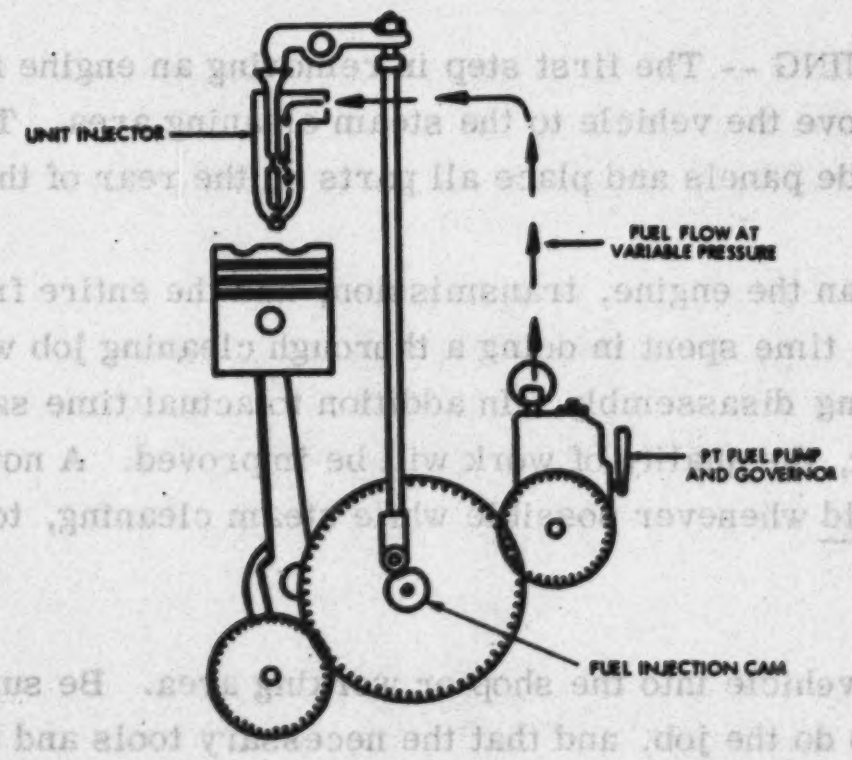


Fig. 10 Pressure-time unit injector.

PART II -- UNIT REPLACEMENT (ENGINE)

SECTION A -- PREPARATION FOR REMOVAL

This portion of the unit will cover the steps the maintenance man must know when he is removing engines from Euclid 14 or 15 FFD trucks or Mack LYSW and M 45 trucks. Many of the procedures apply to both vehicles and to other types of vehicles as well. Some maintenance and safety precautions will also be inserted throughout this section.

STEAM CLEANING -- The first step in removing an engine from any vehicle is to move the vehicle to the steam cleaning area. Then remove the hood and side panels and place all parts on the rear of the truck.

Next steam clean the engine, transmission, and the entire front end of the truck. The time spent in doing a thorough cleaning job will be made up quickly during disassembly. In addition to actual time saved by engine cleaning, the quality of work will be improved. A note of caution - use a face shield whenever possible while steam cleaning, to avoid accidents.

Next move the vehicle into the shop or working area. Be sure there is enough room to do the job, and that the necessary tools and equipment are available.

GOOD SHOP PRACTICE -- Before proceeding with the removal of the engine, since we are in the shop, let's discuss some good practices thata maintenance man must follow if his shop is to be efficient and accident-free.

Whether the job is big or small, it will be to the advantage of each maintenance man to keep the following rules in mind:

1. Remember that pneumatic and electrical impact wrenches are particularly useful in engine disassembly operations. Use them whenever possible.
2. Keep tools neatly arranged in tool racks so that you can select quickly the particular tool that you need. This will save both time and energy.
3. Keep all tools clean, regardless of whether they are your own hand tools or more expensive shop tools. The best way is to keep a clean rag handy and wipe any oil, grease, or dirt from each tool right after it is used rather than waiting to clean all tools and equipment at the end of the shift.

   Actually, cleaning each tool as you use it is a time saver. Placing a dirty or greasy tool back in the tool rack will spread the dirt or grease onto the tool rack and onto other tools resulting in a major clean up job each night. Therefore, the few seconds required to wipe off a tool immediately after use not only saves you considerable time, but also makes your work more pleasant.
4. Avoid compromises. If you do not have the correct size wrench immediately available don't use one that will "probably work." Don't settle for a pair of pliers, an adjustable wrench or knuckle buster, or a wrench of the wrong size just because it's handy. Using such tools is the cause of many accidents and personal injuries, as well as damage to engine parts.
5. Keep the engine at a convenient height after it is removed from the vehicle. Do not set it on the floor. Use an engine stand; see Figure 11.
6. Check engine lifting equipment frequently to be certain that it is absolutely safe. If any failures are discovered, such as an inoperative switch, a sprung hook, frayed cables, or kinked chains, report then immdeiately.
7. Place all bolts, capscrews, and other small parts with their related units in fine mesh wire baskets. Tag each unit and each basket of small parts with a job number or some other means of of identification so they cannot be lost.
8. As the larger parts are removed, place them on a parts cart. Keep them clean, and off the floor.

COOLING SYSTEM DRAINING -- The next step is to drain the cooling system. Care should be taken when removing the radiator cap. If the engine is hot, there is a chance that hot coolant may be sprayed and cause serious burns. Before opening drain cocks, see Figure 12, retain the antifreeze coolant by draining into a container.

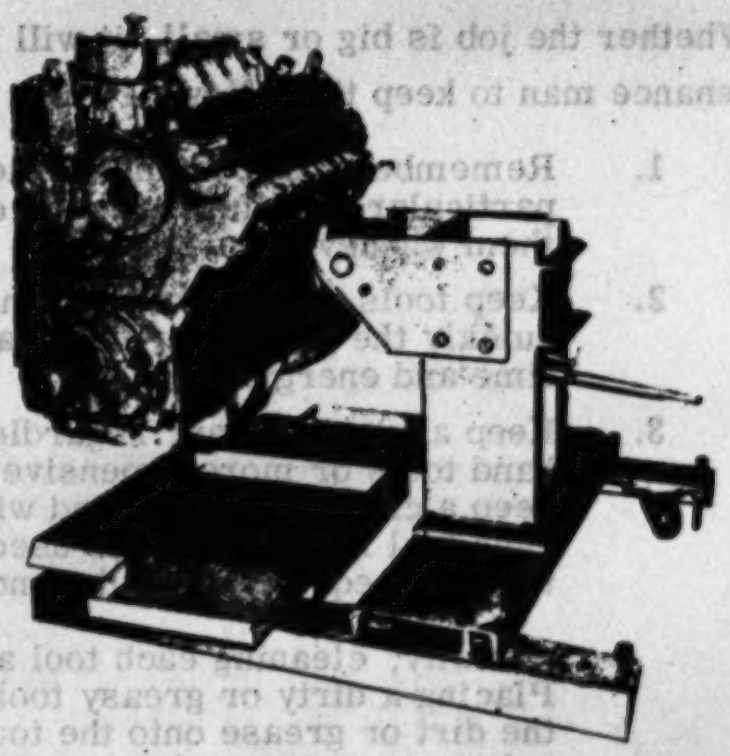


Fig. 11 Engine mounted on stand.

RADIATOR REMOVAL -- After all coolant has been drained, remove the radiator. The following steps are to be followed in sequence:

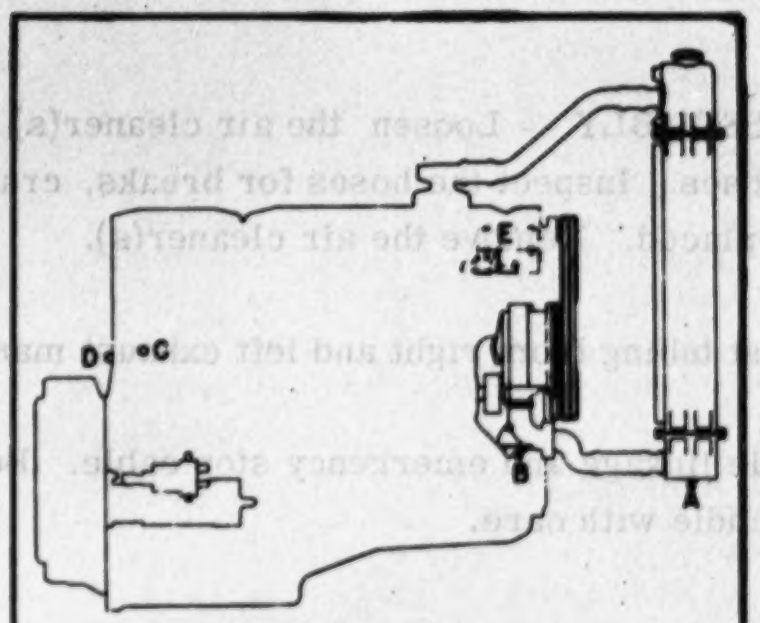
1. **Loosen the top and bottom radiator hose clamps and remove hoses.**
2. **Loosen the block heater hose clamps and remove hoses.**

NOTE: While removing the radiator and block hoses, inspect them for wear and damage, tag the ones that need replacing.

3. **Attach a chain hoist and a suitable hook (through the filler neck or otherwise) and draw the hoisting chain taut to steady the radiator.**

NOTE: On some applications, the shroud housing and the fan assembly will have to be removed prior to removing the radiator.

4. **Remove nuts from mounting studs and brace rods which attach the radiator to the engine base. Lift radiator and shroud from unit.**



A-Drain Cock on Bottom Tank
B-Drain Cock at Bottom of Water Pump-Lower Right Front of Engine
C-Hex Head Machined Plug in Right Side at Rear of Engine Block
D-1/2" Pipe Plug-Rear Engine Block
E-1/4" Pipe Plug in Air Compressor

Fig. 12 Typical engine drain points.

CAUTION: Use care in lifting radiator assembly from area of fan blade, these parts can be damaged easily.

5. Move radiator assembly to storage rack.

ENGINE TO ACCESSORY ATTACHMENTS REMOVAL -- Next tag and remove steering booster hose, cab heater hoses, lubrication oil line to pressure guage, air line to governor, copper air line to brake tanks, air line to starter, and air line to starter valve.

NOTE: Be sure to inspect all hoses and tag hoses to be replaced. Plug all hoses to keep out dirt.

CAUTION: Clean up any spilled oil immediately to prevent injury to personnel.

WIRING REMOVAL -- Next remove temperature guage thermostat, couple-generator-fuel solenoid high temperature and low oil pressure switch wiring. Be sure to tag all wiring and inspect for cracking, breaking and fraying.

AIR CLEANER ASSEMBLY -- Loosen the air cleaner(s) hose clamps, and remove the hoses. Inspect the hoses for breaks, cracks, etc. Tag all hoses to be replaced. Remove the air cleaner(s).

Disconnect exhaust tubing from right and left exhaust manifolds.

Disconnect throttle linkage and emergency stop cable. Be careful not to bend linkage. Handle with care.

SECTION B -- UNIT REMOVAL

ENGINE REMOVAL -- The next step is to loosen and remove four bolts from the front engine support. With this complete, and a quick recheck to be sure all required steps have been done prior to removal, position overhead crane and with a four way spreader, hook up to the four lifting eyes on engine. Take up slack on crane till chains are taut.

Remove 12 capscrews which fasten the flex plate to the flywheel. Block up transmission and remove capscrews which fasten the transmission housing to the flywheel housing.

CAUTION: Use proper blocking to prevent transmission from slipping before removing the 23 capscrews.

As a safety measure, clean up entire area and make a final check of cables and hookup before continuing.

Remove 8 capscrews from rear engine mounts and lift engine from truck. Steam clean the engine thoroughly and transfer it to an engine cart. Move engine to rebuild area.

INSPECTING THE FRAME -- Inspect the frame tubes and engine mount brackets for cracks and wear. Weld worn or cracked areas if required.

CAUTION: Before welding, be sure area has been cleaned and that the proper fire extinguishing equipment is close at hand.

This has been a brief presentation of how to correctly remove an engine. Later on in the course when we discuss major repair of engines there will be more on this subject.

DIDACTOR PLATES FOR AM 1-11D

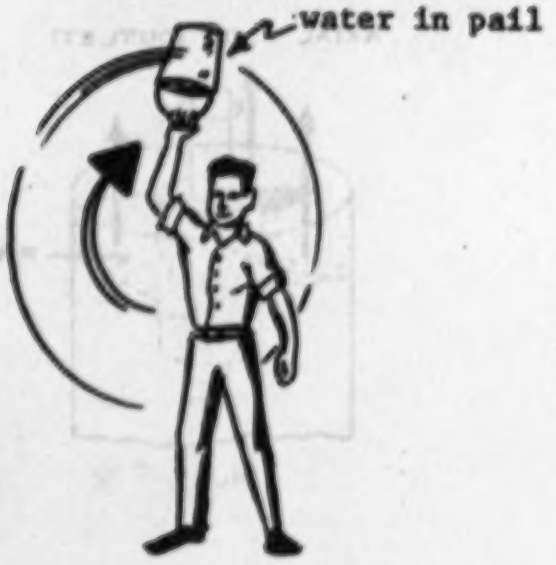


Plate I Centrifugal force holds water in the pail.

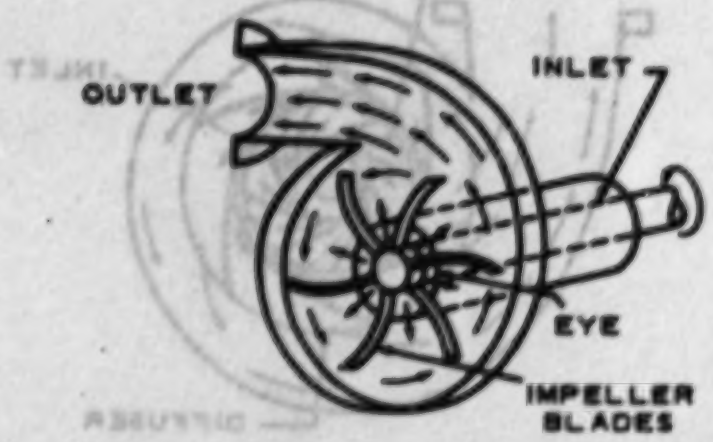


Plate II Volute type of centrifugal pump.

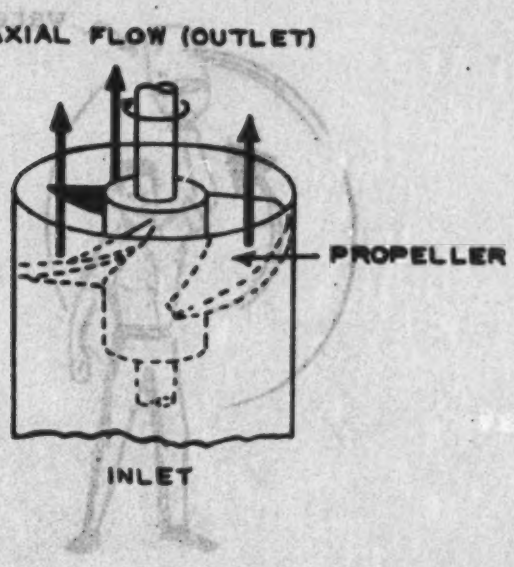


Plate III Propeller pump.

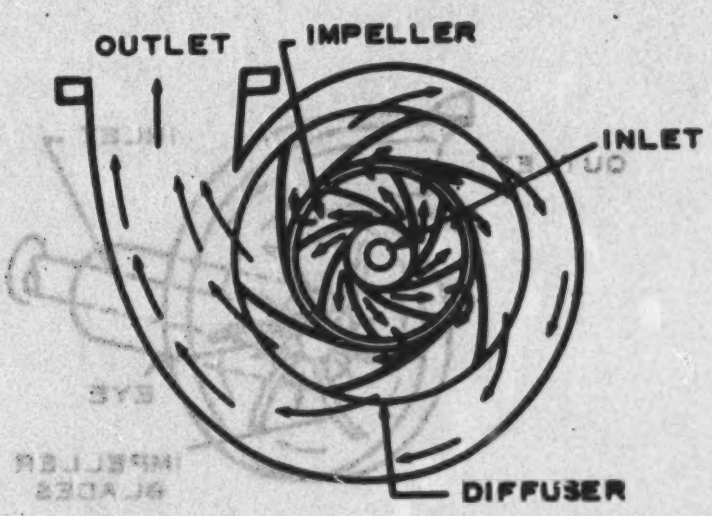


Plate IV Diffuser type of centrifugal pump.

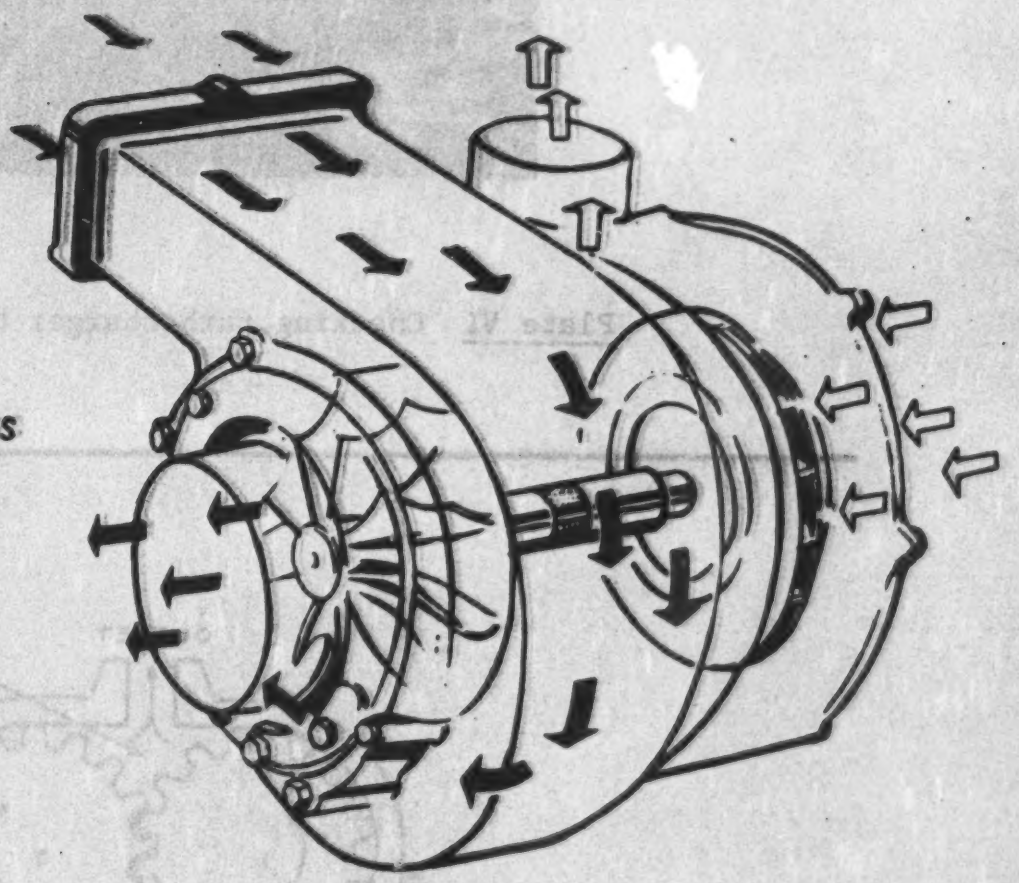


Plate V Cummins turbocharger.

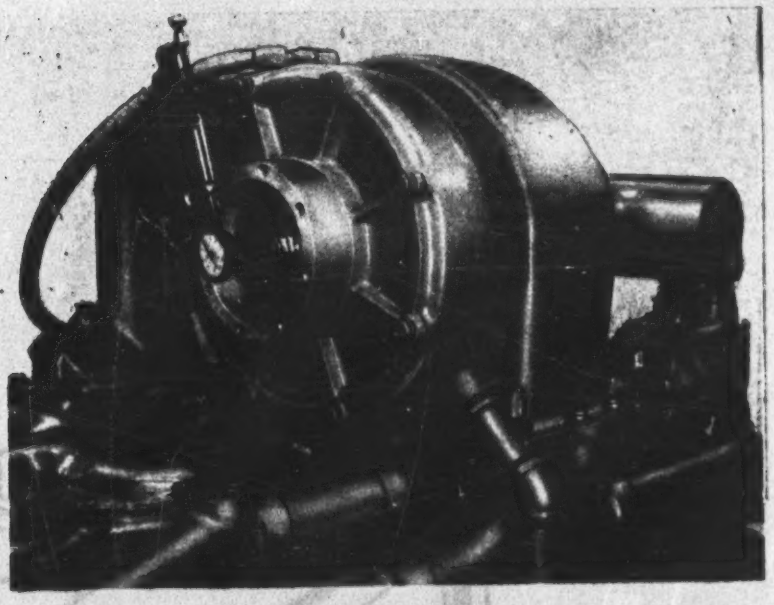


Plate VI Checking turbocharger bearing clearance.

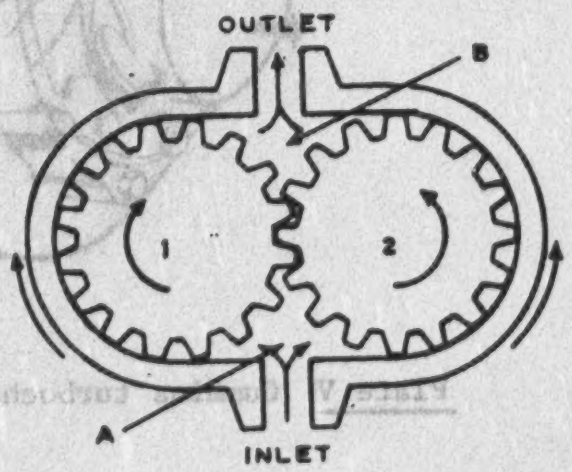


Plate VII Operation of an external gear pump.

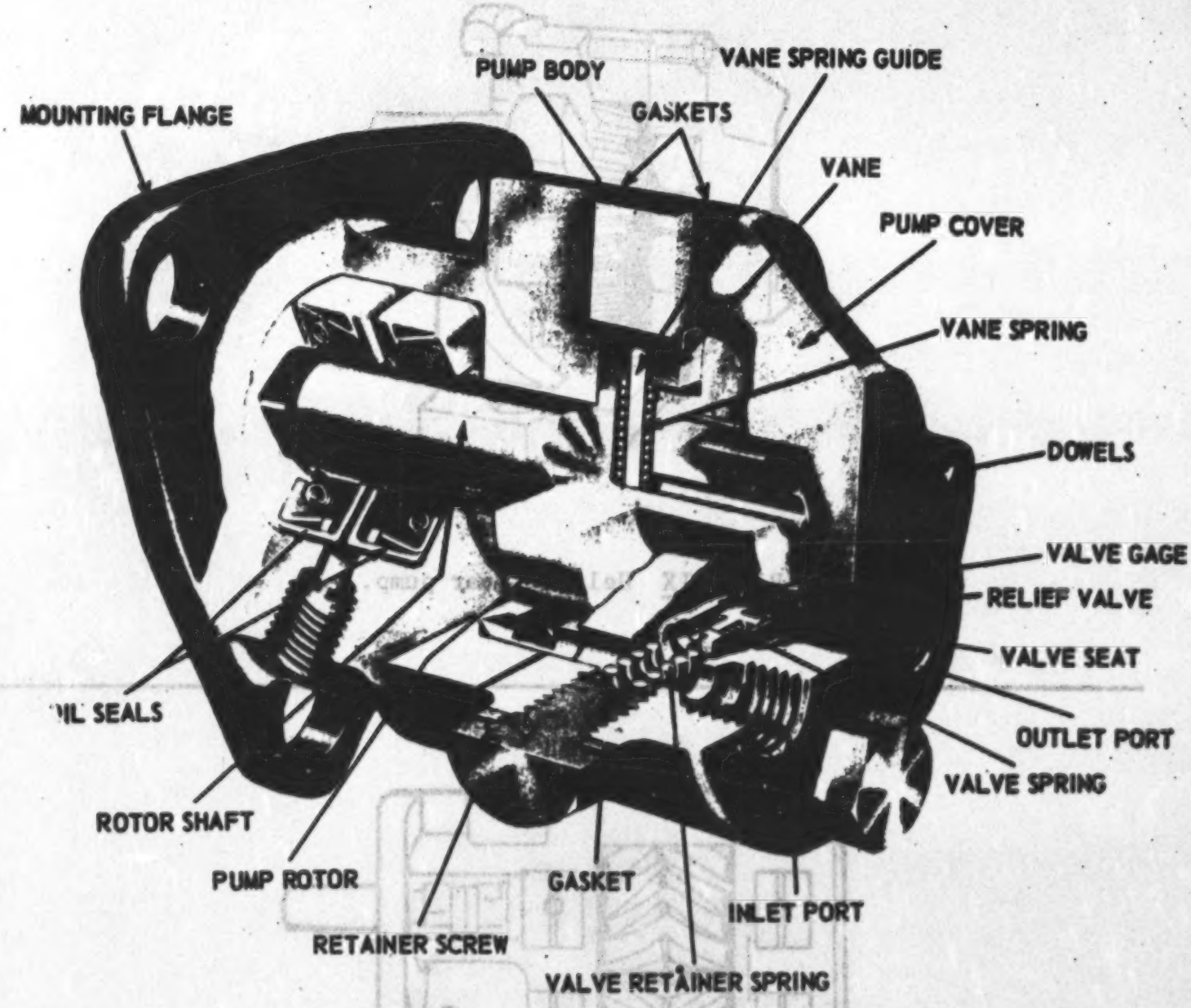


Plate VIII Relief valve in a vane pump.

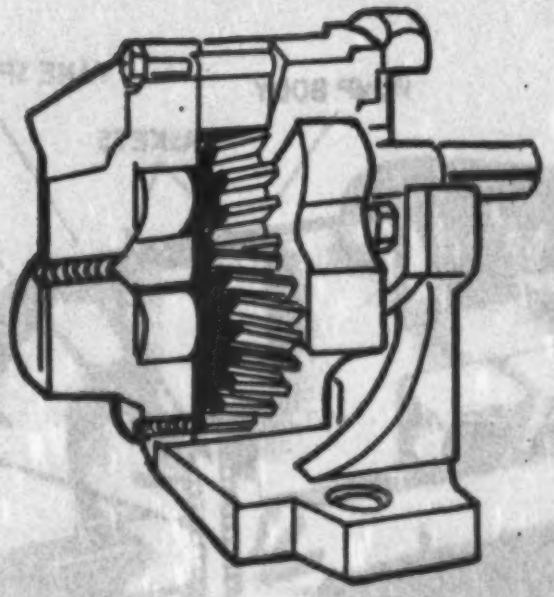


Plate IX Helical gear pump.

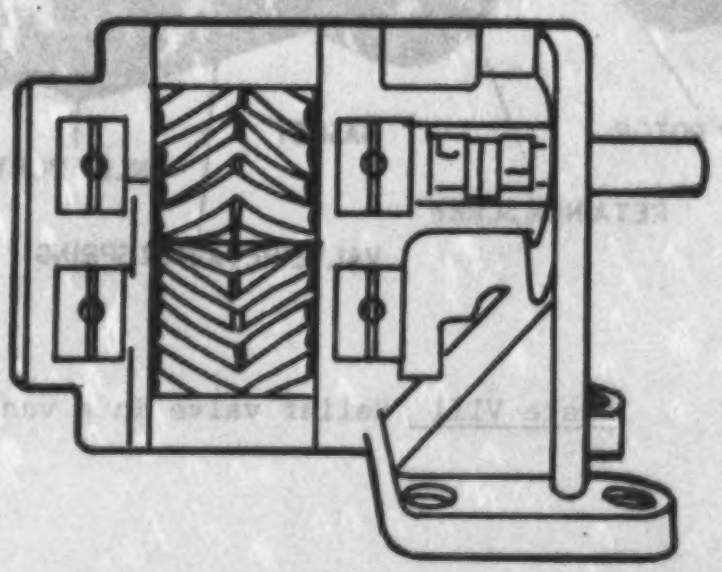


Plate X Herringbone gear pump.

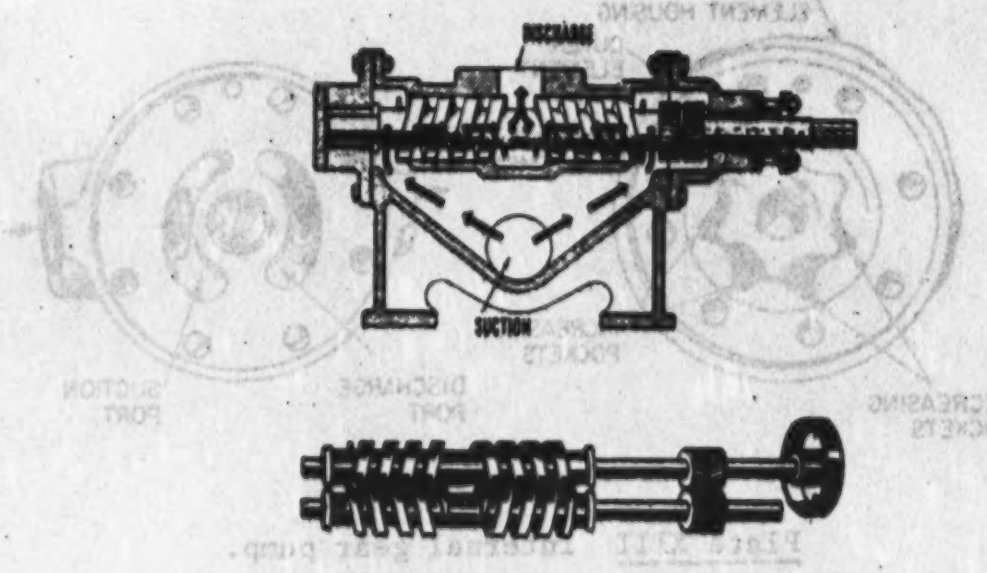


Plate XI Low pitch double-screw pump.

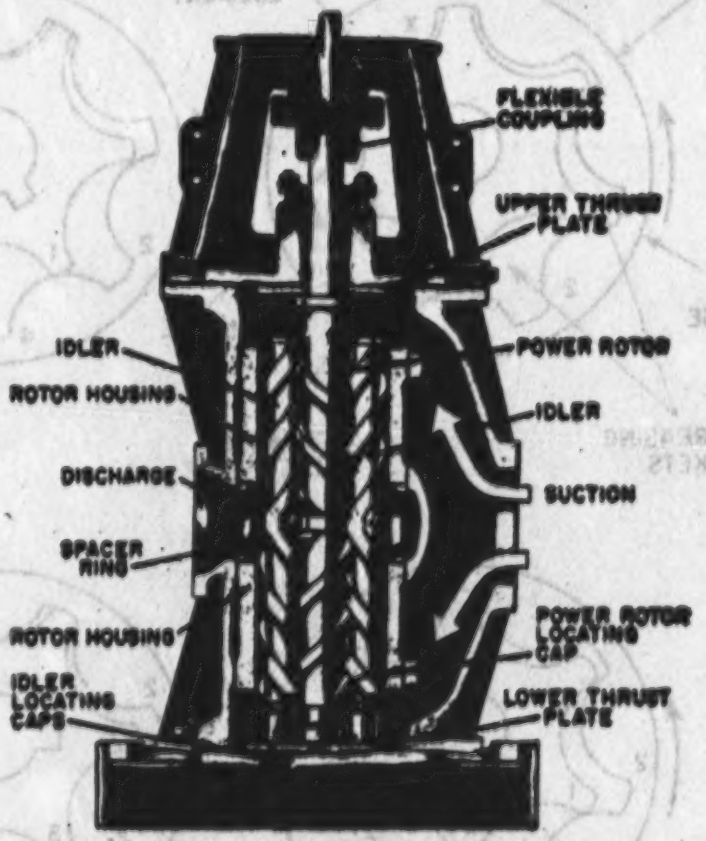


Plate XII Triple-screw high pitch pump.

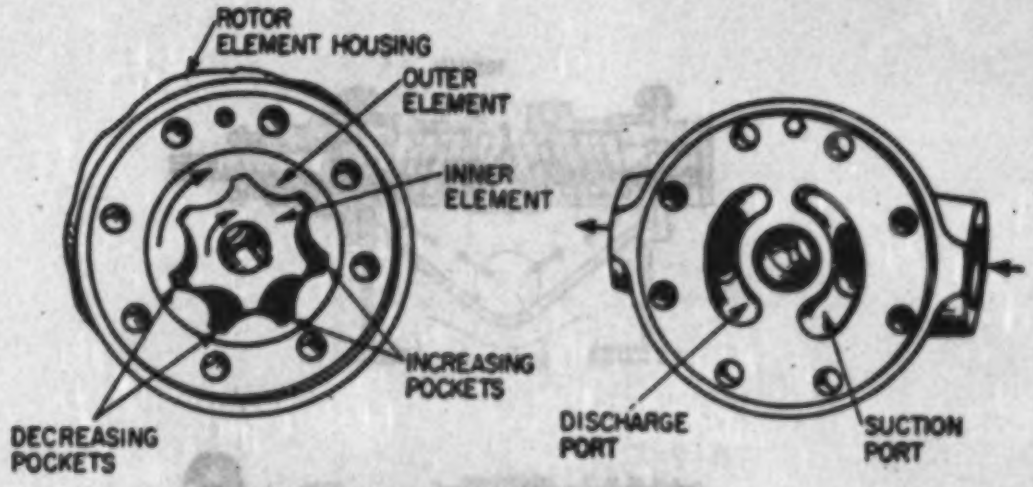


Plate XIII Internal gear pump.

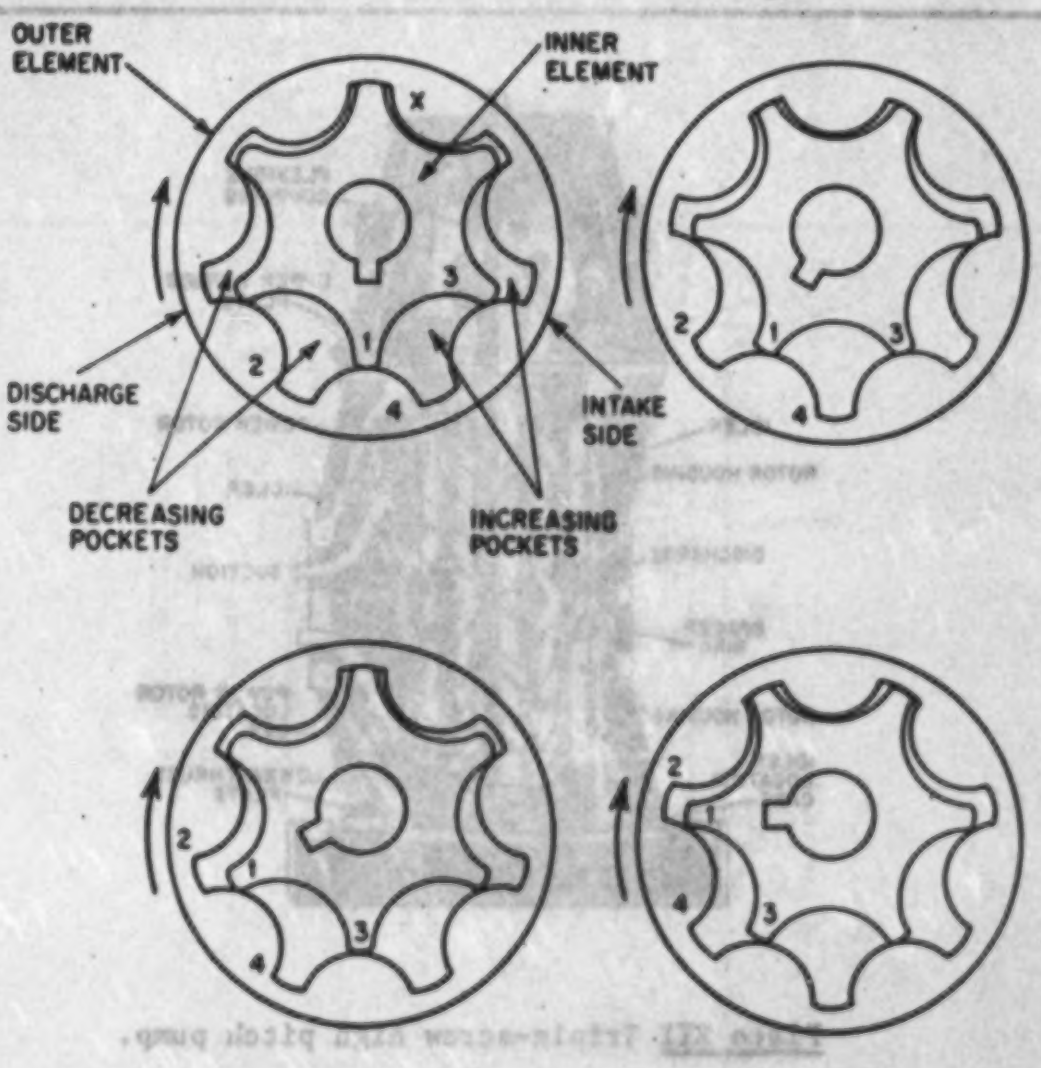


Plate XIV Operation of an internal gear pump.

0

AM 1-11D
1/31/66

UNDERSTANDING BASIC HYDRAULICS IN RELATION TO CUMMINS FUEL PUMPS

Human Engineering Institute

Press A → 1

Check to see that timer is OFF

1

1

In some of the previous films we have briefly covered the science of HYDRAULICS in our discussion of pumps, fluid flow, pressure, restricted fittings, vacuums, and air blowers. This unit, and some to follow, are designed to give the maintenance mechanic a basic working knowledge of hydraulics, so he can better understand why these and other components function.

The word medium will be used to represent air or fluid throughout this film.

Press A → 2

1

2

The heart of every hydraulic system is its pump. The pump generates the force which is needed by the medium to do its work in operating a cylinder or pressurizing a system.

The pump changes mechanical energy into pressure energy by performing two functions. Its mechanical action creates a partial vacuum at the pump inlet, which enables atmospheric pressure in the reservoir to force the medium through the inlet line into the pump. Then it delivers this medium to the pump outlet and forces it into the system, thereby developing the force to produce motion in the area where it is needed.

Press A → 3

1

3

Some of the mechanical energy which a pump transforms into pressure energy is lost in mechanical and medium friction. Also some of the generated power is unavoidably wasted in control functions. Therefore, energy transfer is never 100 percent efficient. Most pumps operate at somewhere between 70 and 85 percent efficiency.

Most pumps for diesel powered vehicles are either chain or belt driven, or direct drive propelled from the gear train. An example of this is the Cummins PT pump being driven by the camshaft gear.

Press A → 4

1

4

In order for a pump to work effectively in any hydraulic system, it must change_____.
(Choose one.)

A. pressure energy into mechanical energy. → 5
B. potential energy into medium pressure. → 5
C. mechanical energy into pressure energy. → 6

1

5

No. You are not reading as carefully as you should. Read over the information again and think before you answer.

Press A → 2

1

6

Correct. The pump changes mechanical energy into pressure energy by performing two functions. First, its mechanical action_____.

A. increases the atmospheric pressure in the reservoir. → 7
B. creates a partial vacuum at the outlet side of the pump. → 8
C. creates a partial vacuum at the inlet side of the pump. → 9

1

7

No. A pump within a system cannot change the atmospheric pressure, it can only create a situation that makes atmospheric pressure work.

Try this question again.

Press A → 6

1

8

No. Think about your answer. When you are sucking a medium through a straw, where is the vacuum created, on the inlet or the outlet end of the straw?

Try this question again.

Press A → 6

1

9

Correct. The vacuum is created on the inlet side of the pump, this allows _____ pressure to force the liquid or air through the inlet side of the pump.

A. medium → 10
B. mechanical → 10
C. atmospheric → 11

1

10

No. Read over the information again and think before you answer. Read carefully.

Press A → 2

1

11

Correct. Atmospheric pressure in the tank forces the medium to the point of vacuum and through the pump.

When a pump is operating in a system, it is never 100% efficient because some of the generated power is lost through _____.

A. design of the pump. → 12
B. mechanical and medium friction. → 13
C. normal pump operation. → 12

1

12

No. Remember we said no matter how perfect the pump was designed, there is always a certain amount of mechanical and medium friction present.

Press A → 13

1

13

Correct. Mechanical friction is an important consideration when designing any hydraulic system; the longer the piping, the farther the fluid or air has to travel; result more friction.

Pumps generally are rated in terms of volumetric output. The volumetric output of a pump, often referred to as its "delivery rate" or "capacity", is the amount of medium the pump can deliver at its outlet port per unit of time, at a given drive speed, given displacement and given pressure. Most pumps are rated to give a specific volume at zero psi.

Press A → 15 X C → 14

14

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review this material again to establish it in your mind before going on. Read carefully and think before you answer.

Press A → 2

1

15

VOLUMETRIC OUTPUT for a specific pressure rating usually is expressed in terms of gallons per minute (gpm) or cubic inches per minute (cipm) at a stated pressure (psi), and speed (rpm). For example, a pump may be rated as follows:

1. A certain pump is said to deliver 4.5 gpm at 1000 psi at 1200 rpm. This means that the pump will deliver 4.5 gallons of fluid per minute at its outlet port at 1000 pounds pressure per square inch when it is driven at 1200 revolutions per minute.
2. If the rating is given in cubic inches per minute (cipm) we have to convert to the number of gallons per minute by dividing the cipm by 231 (the number of cubic inches per gallon). Thus a rating of 1039.5 cipm is the same as 4.5 gpm.

Press A → 16

2

16

Since changes in pump drive-speed affect volumetric output, pumps are sometimes rated according to displacement. PUMP DISPLACEMENT is the amount of liquid or air the pump can deliver per cycle. Since most pumps use a rotary drive, it is usually expressed in terms of cubic inches per revolution (cipr).

Pumps usually are rated in terms of _____ output which is often referred to as its _____ or _____. Choose one.

A. pressure, rpm, psi → 17

B. volumetric, delivery rate, capacity → 18

C. cycle, rpm, specific pressure → 17

2

17

No. Remember we said a pump is usually rated in terms of volumetric output, often called its delivery rate, or capacity. Read carefully and think before you answer.

Press A → 18

2

18

OK. Now let's move on to various types of pumps.

Although there are many different ways of classifying pumps, a fundamental division of pumps can be made according to their performance. Pumps can be classed as NON-POSITIVE DISPLACEMENT pumps and as POSITIVE DISPLACEMENT pumps.

An example of a positive displacement pump is the roots blower which GM uses on their engines. This pump produces a PULSATING flow, but since it provides a positive internal seal against slippage, its output is relatively unaffected by system variations.

Press A → 19

2

19

An example of a non-positive displacement pump is the TURBOCHARGER unit that is optional equipment on a Cummins engine. This pump produces a continuous flow, but since it does not provide a positive internal seal against slippage, such as the roots blower, its output varies considerably as pressure varies.

If the outlet port of a non-positive displacement pump were blocked off to stop flow, pressure would rise and volumetric output would decrease until the force resisting flow equalled the pump forced developing flow. Although the mechanical action of the pump would continue, the slippage factor would allow a full release of the volumetric output back to the input side so that the pump would cease to produce flow into the system.

Press A → 20

2

20

The main difference between a positive displacement pump, and a non-positive displacement pump is _____.

A. the positive pump's output varies as system pressure varies. → 21

B. the non-positive pump's output varies as system pressure varies. → 23

C. the positive pump has slippage. → 22

[redacted]

2

21

No. You are not reading as carefully as you should. Review this information again, and think before you answer.

Press A → 18

2

22

No. Think about the roots blower for a minute, does it have internal slippage, can the air leak back into the input side once it is trapped? Try this question again after reading the information over.

Press A → 19

2

23

Good. Now let's learn more about pumps.

Three distinctive characteristics of positive displacement pumps are:

1. The volume of medium displaced per revolution is theoretically constant. The capacity of a positive displacement pump is the product of this displacement per revolution and the speed of operation. This may be expressed as cipr x rpm.

2. The pressure developed by the pump is a function of the imposed load. Pressure is the result of load or resistance to flow. (The pump does not create pressure.)

Press A → 23½

2

23½

(Characteristics of positive displacement pumps, continued):

3. The pump is capable of large force multiplication.

Positive displacement pumps, in general, can be classified as ROTARY or RECIPROCATING. In a rotary pump, a rotary motion carries the medium from the pump inlet to the pump outlet. In a reciprocating pump, a reciprocal (back and forth) motion carries the medium from the inlet side of the pump to its outlet side.

Press A → 24

2

24

Two characteristics of a positive displacement pump are that (1) the volume of medium displaced per revolution is theoretically _____, and (2) that the pump _____ pressure.

A. (1) constant; (2) creates → 25
B. (1) variable; (2) does not create → 25
C. (1) constant; (2) does not create → 26

2

25

No. You are not reading as carefully as you should. Read over the information again and try this question again.

Press A → 23

2

26

OK. Now you are getting it. An example of a ROTARY pump, would be like (1) _____ type, whereas a RECIPROCATING pump would be like a (2) _____ pump. Choose one.

A. (1) the roots blower; (2) bicycle → 29
B. (1) a gear; (2) roots blower → 27
C. (1) an air compressor; (2) gear → 28

2

27

No. Remember we said the roots blower was a rotary pump; it has no back and forth action. The lobes are stationary and always turn in one direction like a gear pump.

Press A → 29

2

28

No. Remember we said a reciprocating pump has a back and forth action, like a bicycle pump. The gear pump always moves in one direction and is stationary.

Press A → 29

2

29

OK. You are correct. A bicycle pump has a piston in it that moves up and down, this is a reciprocating pump.

Let's move on to learn more about NON-POSITIVE DISPLACEMENT pumps which may be of the centrifugal, propeller, or mixed flow types. This distinction applies to the type of motion by which liquid is moved from the inlet to the outlet side of the pump's operating mechanism.

To produce pressure, centrifugal pumps depend on the basic law of INERTIA: A body at rest tends to remain at rest, and a body in motion tends to continue in motion with the same velocity and in the same direction.

Press A → 31 X C → 30

3

30

You have answered one or more of the questions in this sequence of material incorrectly. You will be reviewing it again now, so read carefully and think before you answer.

Press A → 15

3

31

Look at the drawing in Plate I, in the back of your class text, AM 1-11. It shows that if a man swings a pail of water, the water will remain in the pail, if the rate of rotation is rapid enough to produce centrifugal force. Velocity of rotation has much to do with the water in the pail. If the bottom of the pail were to come loose at some point, the water would go off at a tangent to the circle of rotation.

In Plate II a place for the "bottom to come off," or a discharge has been provided. At the same time, a place has been provided for fluid to enter as the pressure is lowered by loss of fluid at the outer edge.

Press A → 32

3

32

Now let's look closer at centrifugal pumps.

Notice in Plate II again, that there is a circular pumping chamber with a central inlet port and a surrounding outlet port. A rotating impeller, having a number of curved blades radiating off a center hub, is located in the pumping chamber. These blades usually curve away from the direction of rotation. The chamber formed between the casing and the center hub continuously expands in the direction of the outlet and is called the "volute".

In operation, liquid enters the pumping chamber through the central inlet or "eye" and is trapped between the whirling impeller blades. Centrifugal force throws the liquid outward at high velocity, and the casing contour directs the moving liquid through the outlet port. This type of pump is typical of those used for pumping water for cooling systems on diesel engines.

Press A → 33

3

33

PROPELLER PUMPS -- The action of this non-positive displacement pump is somewhat similar to that of the centrifugal pump, except that the blades sweep the liquid axially through the pump rather than radially, see Plate III. Its action may be compared to that of a ventilating fan enclosed in a tube.

MIXED FLOW PUMPS -- The principles of operation of the propeller pump and the centrifugal pump are sometimes combined by a variation in the angle of the impeller blades so that the flow is both axial and radial, see Plate IV.

Press A → 34

3

34

In a centrifugal type pump such as shown in Plate II the flow of the medium is caused by _____.

A. the centrifugal force and the casing contour. → 37
B. the pressure built up by the impeller → 35
C. the pressure of the medium flowing into the pump. → 36

Choose one.

3

35

No. The impeller in the pump does not build up pressure; the centrifugal force throws the medium in an outward direction. When this medium hits the casing contour, it is directed out. Read this over again carefully to be sure you have it, then try the question again.

Press A → 32

3

36

No. The medium flowing into the pump has no pressure as such. It is merely displacing the vacuum created on the inlet side of the pump. Try this question again.

Press A → 34

3

37

OK. Now you have it. In the pump shown in Plate II, the "volute" refers to the _____.

A. slant of the impeller blades. → 38
B. casing contour. → 40
C. axial flow of the medium. → 39

3

38

No. You are not reading as carefully as you should. Read the information over again carefully and then try this question again.

Press A → 32

3

39

No. The axial flow of the medium has nothing to do with it. It is the shape or contour of the pump casing. Read the information over and then answer this question again.

Press A — 32

3

40

OK. Another type of centrifugal pump similar to the volute type is the DIFFUSER type pump. This pump (see Plate IV) incorporates a series of stationary blades termed the "diffuser". The stationary diffuser blades curve in the opposite direction from the direction of the whirling impeller blades. The diffuser serves to reduce the velocity of the medium, decrease the slippage, and increase the pump's abilility to develop flow against resistance.

3

Press A —

41

Plate IV shows the diffuser type pump principle in the Cummins turbocharger unit. A turbocharger is nothing but an air pump designed to put more air into the diesel cylinders. It operates on hot exhaust gases being released from the exhaust manifold. The hot exhaust gases (red arrows) pass through the turbine chamber. The force of the gases on the turbine blades turns the turbine wheel and shaft. This turning rotates the impeller of the centrifugal blower, creating a vacuum and drawing air into the casing (black arrows) and forcing it into the intake manifold and cylinders.

Press A — 42

3

42

In the diffuser type pump, such as a Cummins turbocharger, the diffuser arrangement serves to (1) the velocity of the air, (2) the slippage, and (3) the pump's ability to develop flow against resistance. Choose one.

A. (1) reduce; (2) decrease; (3) increase — 44
B. (1) decrease; (2) reduce; (3) lower — 43
C. (1) increase; (2) decrease; (3) increase — 43

3

43

No. You are not reading as carefully as you should. Review this information again about the diffuser type pump and then try this question again.

Press A — 40

3

44

OK. The power that drives the turbine wheel, which in turn drives the impeller, is obtained from the energy of the (1). The speed of the turbine then would increase as the engine (2).

A. (1) intake gases; (2) slows down. — 45
B. (1) exhaust gases; (2) speeds up. — 47
C. (1) exhaust gases; (2) slows down. — 46

3

45

NO. You are incorrect. The intake gases have nothing to do with the speed of the turbine. Think about the mechanics of the turbocharger for a minute and then try this question again.

Press A — 44

3

46

No. You are incorrect. It is true that the turbine rotates under the pressure of the exhaust gases, but think now, would the turbines rotate faster at slow engine speed or at fast engine speed.

Try this question again.

Press A — 44

3

47

OK. You are correct.

The air being emitted from the impeller of the turbocharger _____.

A. helps to increase the speed of the turbine. — 48

B. adds additional air to the intake manifold. — 50

C. helps to expel the hot exhaust gases at a faster rate. — 49

3

48

No. You are incorrect. The turbocharger has two inlets and two outlets. Fresh air enters the impeller inlet and is forced into the intake manifold. It has nothing to do with the turbine speed.

Press A — 50

3

49

No. You are incorrect. The exhaust gases are expelled into the atmosphere from the turbine casing. The air expelled from the impeller side of the turbocharger has nothing to do with assisting the exhaust gases to escape.

Press A — 50

3

50

OK. Now let's talk about some troubles that might occur with a turbocharger. There are two sleeve type bearings that support the rotor shaft. Both the turbine and the impeller blades are attached to this rotor shaft. The thrust bearing absorbs the force exerted lengthwise or axially along the shaft by exhaust gases striking the turbine blades. These bearings have drilled holes for the passage of lubricating oil.

Press A — 52 XC → 51

51

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you read this material again to establish it well in your mind. Read carefully and take your time in answering.

Press A — 32

4

52

Some of the conditions that might damage these bearings are: insufficient lubrication or dirty oil, and unbalanced rotor, or operation with excessive exhaust temperature. Usually if there is a vibration during operation, it is a good indication that the bearings are damaged.

Bearings should be checked periodically for pitting or excessive scoring and for proper clearance.

Shaft end play may be checked with a dial indicator (see Plate VI) by moving the shaft axially from one extreme position to the other. End clearances greater than .011" for the Cummins T-500 engine indicate wear of the thrust bearing.

Press A — 53

4

53

Wear on the thrust bearing of a turbocharger is the result of pressure being exerted _____. Choose one.

A. axially on the shaft from pressure on the turbine blades. — 56

B. radially on the shaft from air pressure against the impeller. — 54

C. radially on the shaft from pressure on the impeller blades. — 55

4

54

No. You are not reading as carefully as you should. Think now, radial pressure is a downward thrust. Try this question again.

Press A — 53

4

55

No. You are not reading very carefully.

Remember, we said there is no pressure on the impeller blades. Only the turbine blades receive pressure from the exhaust gases.

Try this question again.

Press A -53

4

56

OK. You are correct. More about the turbocharger will be covered in later units. Now let's learn more about POSITIVE DISPLACEMENT pumps.

As we learned earlier, rotary pumps use revolving gears or vaned rotors to force mediums into a system. Also they deliver their rated flow with minor pulsations and pressure surges. The three basic types of rotary pumps are: gear, vane and piston.

Press A - 57

4

57

The gear pump (see Plate VII) is the type most commonly used on diesel engines. The pump consists of a drive gear (1) and a driven gear (2) enclosed in a closely fitted housing. The gears rotate in opposite directions, and mesh at a point in the housing between the inlet and outlet ports. As the gear teeth separate, a partial vacuum is formed, which draws liquid through the inlet port into chamber (A).

Press A -58

4

58

Liquid in chamber (A) is then trapped between the teeth of the two gears and the housing so that it is carried through two separate paths around to chamber (B). As the teeth again mesh they produce a force which drives the liquid through the outlet port. The close mesh of the gear teeth serves to provide a seal between the inlet and outlet sides minimizing slippage.

Press A - 59

4

59

In a gear pump, there are two gears meshing together, (1) of these gears (2).

A. (1) one; (2) is the driver gear, and the other is driven. -62

B. (1) both; (2) are turning in the same direction. - 61

C. (1) both; (2) create pressure on the inlet side of the pump. -50

4

60

No. You are not reading as carefully as you should. If pressure was created on the inlet side, the fluid could not enter. Try this question again.

Press A - 59

4

61

No. Both the gears cannot be turning in the same direction; one has to turn the opposite from the other. Try this question again.

Press A -59

4

62

OK. The separation of the gear teeth causes a (1) on the (2) port of the pump.

A. (1) force; (2) inlet -
B. (1) pressure; (2) outlet - 63
C. (1) vacuum; (2) inlet - 64

4

63

No. As the teeth separate on the inlet side, a vacuum is formed drawing the liquid through the inlet port.

Press A -64

64

OK. The reason for closeness of gear teeth mesh in a gear pump is_____.

A. to eliminate vibration in the pump. -65
B. to increase pressure in the pump.
C. to provide a good seal. -66

65

No. The answer we wanted here is that the closeness of the mesh provides a seal between the inlet and outlet ports.

Press A -66

66

OK. Gear pumps afford very little slippage of liquid. Therefore, if the fuel lines or filters should clog up, there must be a way to relieve the pressure. This is accomplished by having a pressure relief valve inserted in the pump body.

Press A - 67 XC → 66 1/2

66 1/2

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review the material again to establish it well in your mind. Read carefully and take your time in answering the questions.

Press A - 56

4

67

There are many different types of relief valves, but most of them consist of a valve body containing a disk or ball. The compression of a coil spring holds the disk or ball on its seat, under normal pressure conditions. When the pressure in a valve exceeds the resistance of the spring, the disk or ball lifts off its seat and the pressure is reduced until it falls below the pressure for which the valve is set.

Press A -68

5

68 & 68

Plate VIII shows a relief valve in the housing of a vane pump.

Relief valves should be set at the lifting pressure specified by the manufacturer. The tension on the valve spring can be changed by means of an adjusting nut. The nut should be locked when the desired setting is attained. Since the setting for a specific valve will depend on the design of the valve and its use, the instructions in the applicable manufacturer's manual should be followed when a relief valve is being set.

Press A -69

5

69

Continual lifting (popping) of a relief valve indicates either excessive pressure or malfunctioning of the valve. Either condition should be corrected immediately. A relief valve which is not operating properly should be removed, disassembled, cleaned, and inspected. The disk or ball and the seat should be checked for pitting and excessive wear. The spring should be carefully inspected for possible defects. When a relief valve is removed for any reason, the spring tension must be reset.

Relief valves, must never be locked in the closed position, except in cases of emergency. When emergency measures are taken, the valves must be repaired or replaced, whichever is necessary, as soon as possible.

Press A - 70

5

70

In a pressure relief valve where the ball and spring principle is used, the pressure is relieved when_____.

A. the spring is expanded. — 71
B. the spring is contracted. - 72
C. neither A or B. — 71

5

71

No. You are incorrect. If the spring is expanded, the ball will seat more firmly against the pressure outlet port. Read this part over again and repeat the question.

Press A — 67

5

72

OK. As the pressure exceeds the spring force, the ball is lifted from the seat and excess pressure is relieved.

This type of pump requires a relief valve_____.

A. in case the filters or fuel lines become clogged. — 74
B. due to the slippage factor of the pump. - 73
C. due to the surges of pressure. — 74

5

73

No. You are incorrect. Remember, we said this is a positive displacement pump that has little or no slippage. Because of this, a relief valve must be installed to prevent rupturing the system, in case the system should get clogged.

Press A - 74

5

74

No. Surges of pressure are characteristic of positive displacement pumps. The answer we wanted here was "in case the filters or fuel lines become clogged."

Press A — 75

5

75

OK. Other types of gear pumps are manufactured and used for different applications. One of these is the HELICAL gear pump, see Plate IX. This small capacity, high pressure pump is particularly adapted to industrial trucks, machine tools and construction equipment. Because of the helical gear design, the overlapping of successive discharges from spaces between the teeth is much greater than the simple gear pump. This overlapping provides a much steadier discharge pressure and allows the flow to be smoother.

Press A — 76

5

76

Like the helical pump, the HERRINGBONE pump (see Plate X) gets its name from the cut of the gears. In this pump, one discharge phase begins before the previous discharge phase is entirely completed. This overlapping tends to provide a steadier discharge pressure than is obtained with a simple gear pump. In addition, the power transmission from the driving gear to the driven gear is smoother.

Press A - 77

5

77

In the herringbone and helical type gear pumps, the overlapping of the gears permits_____.

A. more slippage than the simple gear pump. - 78
B. a steadier discharge pressure. - 80
C. a higher volume output. — 79

5

78

No. We are talking about positive displacement pumps, pumps that have very little slippage. It's the non-positive displacement pumps that have the slippage.

Try this question again.

Press A 77

5

79

No. Remember, we said the helical type pump is particularly adapted to small capacity, high pressure situations, such as machine tools, and construction equipment.

Try this question again.

Press A 77

5

80

OK. You are correct.

Another type of positive displacement pump is the SCREW type. These pumps vary in design according to the number of inter-meshing screws, the pitch of the screw (low or high pitch), and the general direction of the fluid flow (single or double flow).

The LOW PITCH, double screw pump is shown in Plate XI.

Press A 82 X C → 81

81

You have answered one or more of the questions in this sequence of material incorrectly. It will be best for you to review this portion before moving on, to get it established in your mind. Read carefully and take your time in answering.

Press A 67

6

82

The two pairs of screws in the screw type pump which intermesh with close clearances, are mounted on two parallel shafts. Each pair of screws has opposite threads with respect to the other pair. One shaft drives the other through a set of herringbone timing gears, which maintain clearances between the screws as they rotate.

All clearances are small; there is no actual contact between the screws, or between the screws and the casing.

Press A 83

6

83

The liquid is trapped between the grooves of the screws and the casing as illustrated by the arrows in Plate XI. The meshing of the threads of the two screws forces the liquid along the grooves, toward the center (discharge side) of the pump. Notice in Plate XI, that the liquid enters the thread grooves at both ends of the rotors or screws; thus the axial thrust of the two sides is balanced.

Press A 84

6

84

Plate XII shows a TRIPLE SCREW HIGH PITCH pump. The pitch of the screws is much longer than in the low-pitch type. This allows the center screw (power rotor) to be used to drive the two outer (idler) rotors directly, without external timing gears. The diameters of the idlers are less than that of the power rotor (center).

Press A 85

6

85

The purpose of the herringbone gears on a double screw pump is to _____.

A. serve as the propelling force. → 86

B. maintain clearance between the screws. → 88

C. force the liquid outward. → 87

6

86

No. This pump in its application is usually driven from an outside source, such as the gear train of the diesel engine. The answer we wanted was the herringbone gears maintain clearance between the screws.

Press A -44

6

87

No. You have missed this part completely. The fluid does not move through the herringbone gears in this pump. Try this question again.

Press A -55

6

88

OK. The liquid is forced through the screw pump because of the _____.

A. pressure on the inlet side of the pump. -89
B. the pitch variation of the screws. -89
C. the meshing of the screw threads. -90

6

89

No. Read this portion again and try the question once more.

Press A -53

6

90

OK. Now you're getting it. Let's go on to INTERNAL GEAR pumps.

So far we have mentioned only external gear pumps. Some applications such as diesel engine oil pumps, call for the internal type of pump which is shown in Plate XIII. This pump gets its name from the fact that one gear member revolves inside another, the outer gear having teeth that point toward the axis instead of away from it.

Press A -91

6

91

The inner gear of the internal gear pump is connected to the drive shaft, and drives the outer gear.

Operation of the gear elements is shown in Plate XIV. The inner gear has one tooth less than the outer gear has pockets. The tooth form of each element is related to that of the other in such a way that each tooth of the inner gear is always in sliding contact with the surface of the outer gear. Each meshing pair of teeth engages at only one point in the pump. This is at point (X). Thus, tooth (1) will mesh with tooth (2), tooth (3) with tooth (4), and so on, when each pair reaches position (X).

Press A -92

6

92

At the right side of the point of mesh, pockets of increasing size (suction pockets) are formed as the gears rotate, while on the other side of pockets (discharge pockets) decrease in size. In Plate XIV the pockets on the right are suction pockets, while those on the left are discharge pockets. Fluid is forced out the discharge when the gears mesh at (X).

The inner and outer gears travel slowly with respect to each other, even when the drive shaft is rotating rapidly. These pumps can deliver from fractions of a gallon per minute to more than 100 gpm. Pressures per set of gears (called a stage) are usually limited to 2000 psi for continuous duty. This type of pump may be connected in a series of stages for higher pressures.

Press A -93

6

93

In an internal gear pump, both gears_____ _____.

A. have the same amount of teeth. -94
B. turn in the same direction. -96
C. mesh on all sides of the inner gear. -95

6

94

No. You are not reading as carefully as you should. In the internal type gear pump, only one gear has teeth. The other one contains notches which the teeth mesh into. Try this question again.

Press A - 93

6

95

No. The inner element or gear cannot mesh in all pockets of the outer gear at one time. Look at Plate XIV and you will see that only one of the teeth is fully bottomed into the outer element pockets (at point X). Try this question again.

Press A - 93

6

96

OK. You are correct.

As the pump rotates, the pockets of increasing size are the (1) pockets, and those of decreasing size are the (2) pockets.

A. (1) suction; (2) pressure - 97
B. (1) suction; (2) discharge - 94
C. (1) discharge; (2) suction - 93

6

97

No. Remember, we said that in an internal gear pump the pockets of increasing size are the suction pockets, those of decreasing size are the discharge pockets.

Press A - 98

6

98

OK. You are correct. That completes this film. Additional material on hydraulic principles, gears, pumps, and valves will be covered in other films.

PRESS REWIND - 'end

X c → 55

6

99

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you repeat this information to get it well in your mind. Read carefully and take your time in answering.

Press A → 52

6

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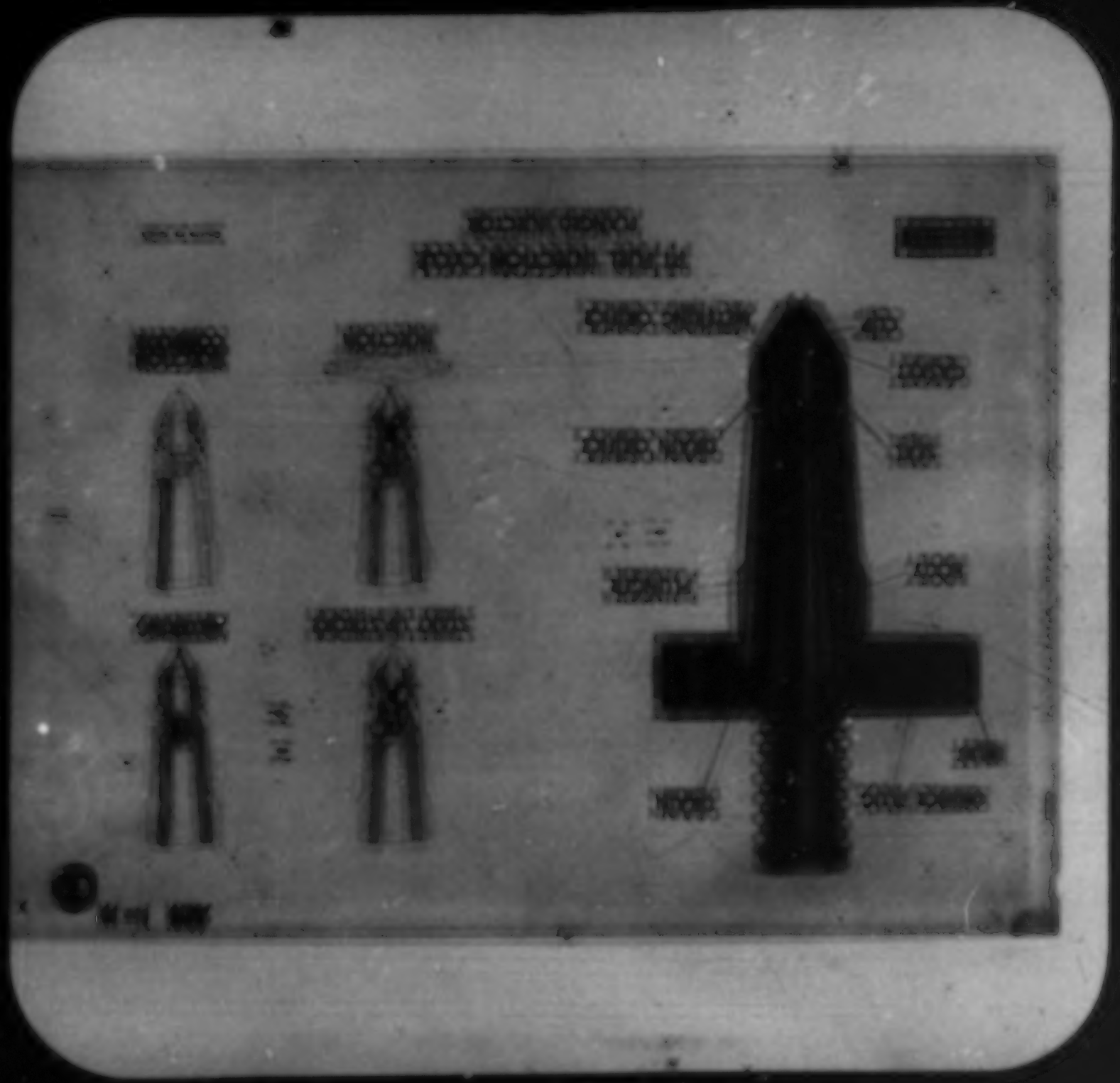

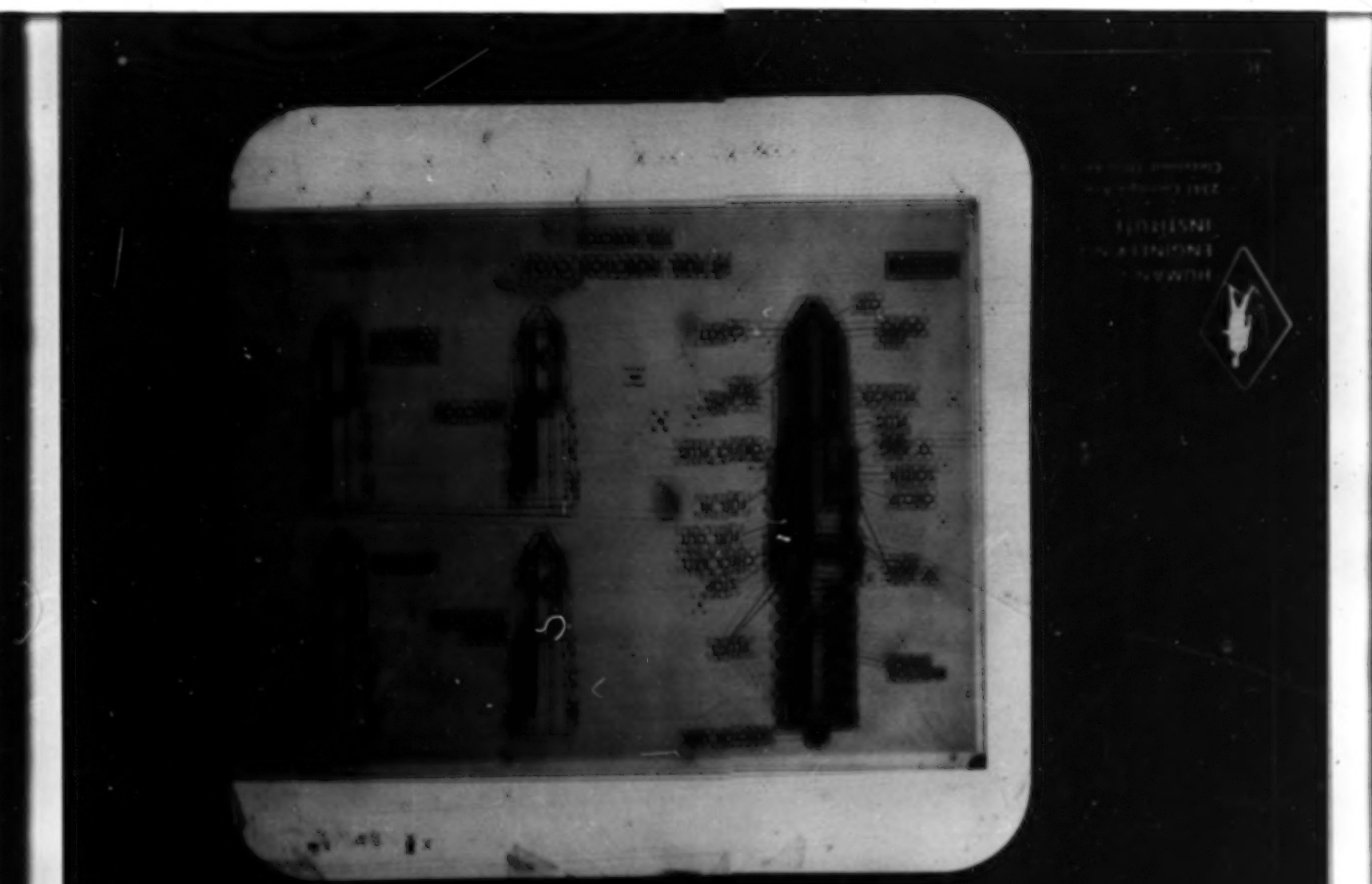

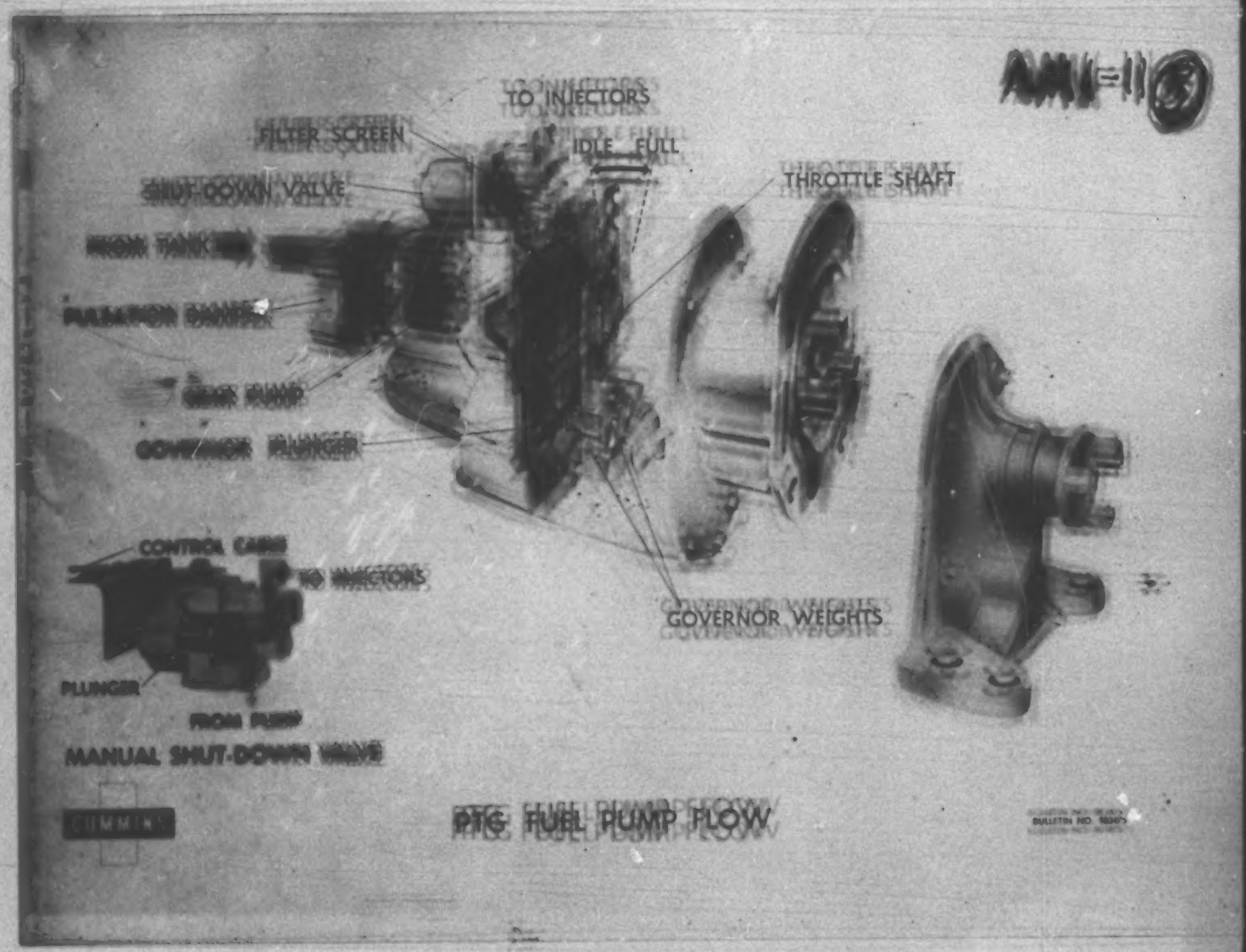

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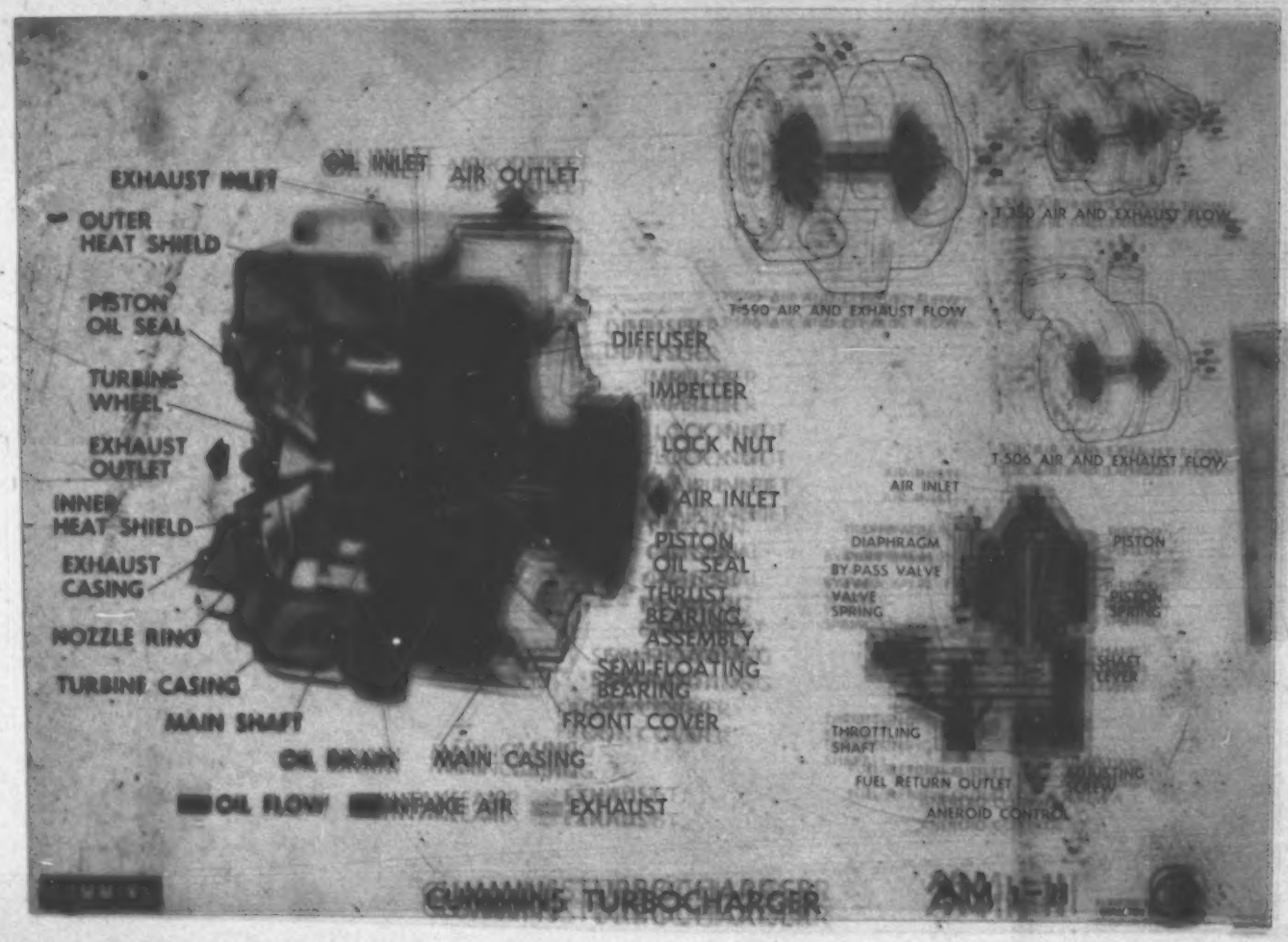

HUMAN ENGINEERING INSTITUTE

INSTRUCTOR'S GUIDE

Title of Unit: Part I - Maintaining the Fuel System (Part I)
Cummins Diesel Engines — AM 1-11
Part II - Unit Replacement (Engine) — 1/ 31/ 66

FIRST: Be sure all questions have been answered that students might have on home study units.

OBJECTIVES: By the end of class, each student should know:

Part I

1. The basic differences between the two and four cycle engine.
2. Know what the letters PTG stand for.
3. Know where the fuel pump is on a Cummins Diesel.
4. Why the governor is used to regulate fuel.
5. How the Cummins fuel system meters fuel in relation to the GM fuel system.

Part II

1. Why it is important to steam clean the engine.
2. What is meant by "Good Shop Practice".
3. What to do first when removing the engine.
4. What safety practices to keep in mind while using hoisting equipment.
5. The importance of keeping all removed parts in an orderly manner.
6. The importance of keeping the area clean at all times.

LEARNING AIDS suggested:

WALL CHARTS:

1. Bulletin #983474, V8-350/VT8-430 Fuel Flow
2. Bulletin #983475, PTG Fuel Pump Flow
3. Bulletin # 983477, PTG Fuel Pump (Mechanical Variable Speed Governor)

VUE CELLS:

1. AM 1-1 (1) (2 cycle vs 4 cycle)
2. AM 1-1 (2) (4 cycle)
3. AM 1-1 (3) (4 cycle)

Instructor's Guide for AM 1-11

VUE CELLS cont'd

4. AM 1-11 (1) (PTG Fuel Pump-Mechanical Variable Speed Governor) 983477
5. AM 1-11 (2) (V8-350 VT8-430 Fuel Flow) 983495
6. AM 1-11 (3) (PT Fuel Injection Cycle-Flanged Injector) 983402
7. AM 1-11 (4) (PT Fuel Injection Cycle-PTB injector) 983500
8. AM 1-11 (5) (PTG Fuel Pump Flow) 983475
9. AM 1-11 (6) (Cummins Turbocharger) 983418

TRAINING FILMS:

1. "CUMMINS ENGINES" - #985516 (16 MM Motion, Color, Sound) 22 minute story which compares gasoline and diesel engines, identification of Cummins engines, what is heat energy and how the engine produces this energy, what horsepower is, and a detailed explanation of the four stroke cycle.

NOTE: Instructor, contact the local Cummins distributor for this film.

MAINTENANCE MANUALS:

1. Inside the Cummins PT Fuel System, Bulletin 983484-A (This booklet is an information guide).
2. CUMMINS - Operation & Adjustment - PT Fuel System, Bulletin #983438-A
3. CUMMINS - V12 Series Operator's Manual
4. CUMMINS - V12 Series Shop Manual

FILM STRIPS:

1. Theory of the PTG Fuel System -- Film # 985509.
2. Principles of a Mechanical Governor -- Film #985511.
3. Operations and Adjust ments of the PTG Fuel Pump-- Film # 985512.

NOTE: Records are available to accompany the above films

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

Part I

1. Why does the four stroke engine require a heavier flywheel than does the two stroke engine?
2. Where does the scavenging air come from in the four stroke engine?
3. In a four cycle engine, is one cycle two revolutions of the crankshaft?
4. What basic principle of hydraulics is the PT system based on?
5. Does the speed of the fuel pump vary with the engine speed?
6. How does fuel get into the fuel pump? Explain.
7. How does the Cummins fuel injector differ from the GM injector?
8. What is meant by pressure-time (PT) ?

Part II

1. What is the first step in preparation for removing an engine?
2. Why save the anti-freeze during an engine overhaul?
3. What is meant by an engine frame tube?